JOURNAL OF

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VOLUME 28 July, 1951 NUMBER 7

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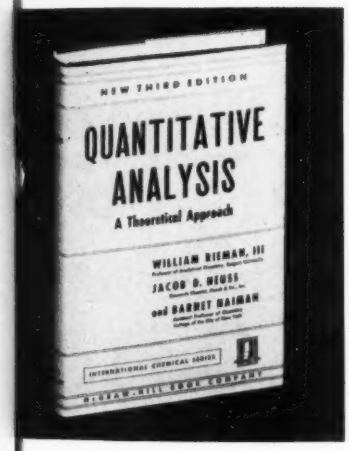

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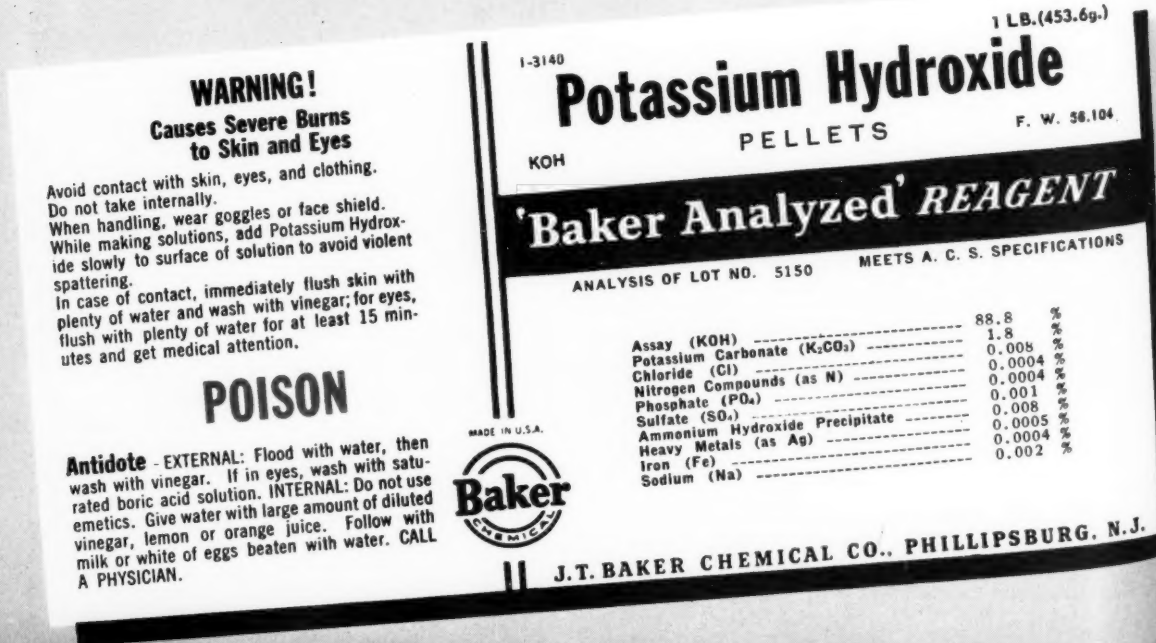
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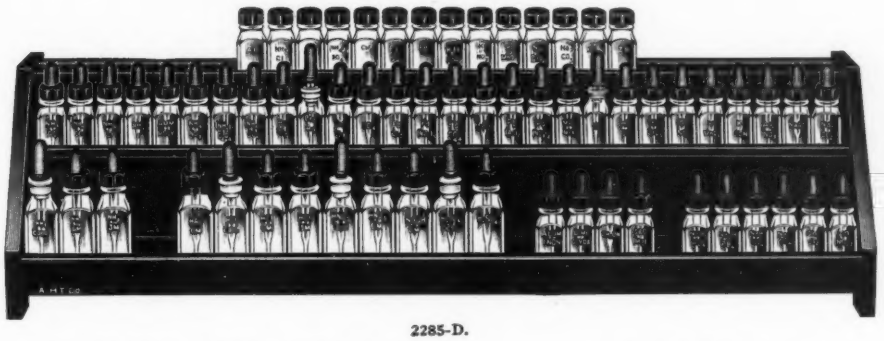

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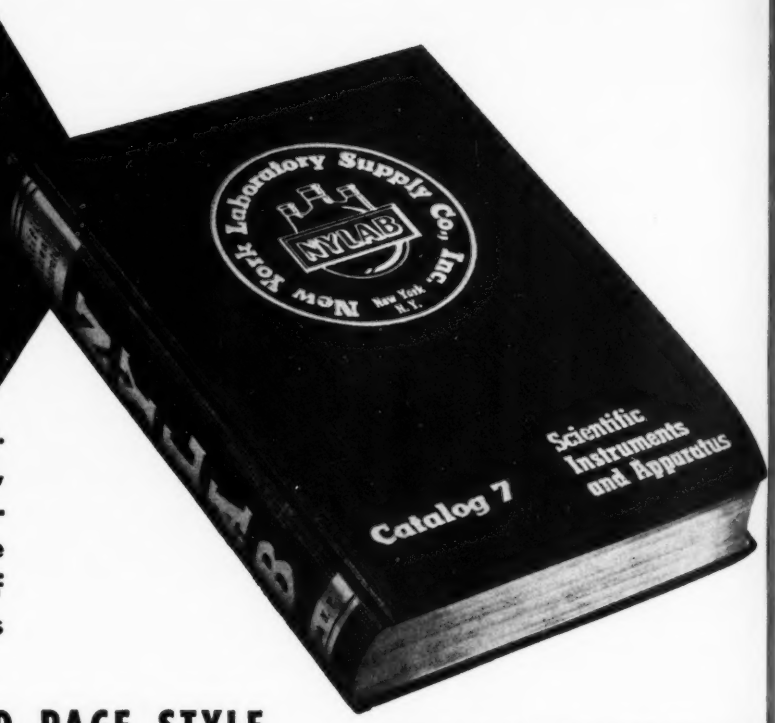

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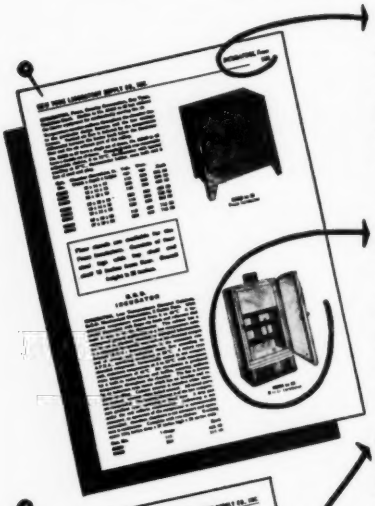

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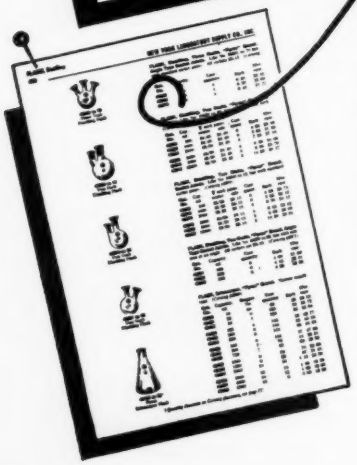

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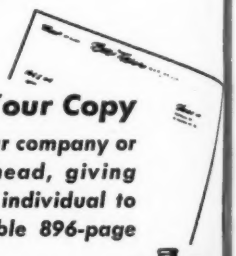

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- **FLEXIBILITY OF CONTROL:** Operating speed, resolution and chart scales can be easily varied over wide ranges. A single control adjusts scanning time per spectral slit width from 1 second to 128 seconds by factors of 2. The wavelength motor speed is electronically controlled with no gear shifting needed to change scanning speed.

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These new "Roller-Type" mills are adjustable through 3 positions enabling units to handle standard jar mills or round containers of 2½" diam. to 15" diam. (roughly from ½ pint to 6 gal. capacity). "Roller-type" Jar Mills are sturdily built with welded steel frames. The rollers are made of a special rubber formulation molded on a ⅝" diam. steel core; they are 12½" long and average approximately 2" in diam. One roller is convex, one concave, and they revolve in heavy duty ball bearings. The entire construction is designed to provide long, trouble-free life, low power costs and minimum upkeep expense.

Outstanding Features

- Will roll any round container—mill jar, bottle, can, etc.
- No clamping in frames or fastening required. Merely place container on the rollers.
- Special patented design of the rollers automatically centers the jar or container—prevents creepage, minimizes breakage.

Ideal for processing, grinding, pulverizing or mixing small batches of WET or DRY materials

GENERAL UTILITY LAB MILL

Powered by a ¼ h.p., 110 volt, 60 cycle open-type motor. Rollers adjustable through 3 positions; handles standard mill jars or round containers of 2½" diam. to 12" diam. (Roller length 12½"). Overall dimensions: 16" long x 14" wide x 16" high. Roller speed approximately 175 R.P.M. Net weight 75 lbs.

CAT. NO. N1930 . . . . $172.50

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Available in 2, 3, or 4 jar units. Handle standard mill jars or round containers from 2½" diam. to 15" diam. Roller speed, 216 R.P.M.

Cat. No.	No. of Jars	Overall Dimensions L	W	H	Motor H.P.	Price AC	DC
N1931	2	54¾"	15"	12⅞"	½	$453.50	$480.50
N1932	3	76¼"	15"	12⅞"	½	551.50	628.50
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Size	Capacity	N1937 Chemical Stoneware	N1938 White Porcelain
00	1 qt.		$17.50
0	.46 gal.	$16.50	20.50
1	1.17 gal.	32.50	40.00
2	2.7 gal.	50.50	62.50
4	4.4 gal.	63.00	76.50
6	6.8 gal.	74.00	100.00

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Average No. per Pound	18
Price per Pound	Less than 100 lbs.—$.88 per lb. 100 to 500 lbs.—$.74 per lb.

Cat. No. N-2132 Flint pebbles. Specially suited for grinding jobs requiring less speed and moderate quality. Exceedingly hard, uniform in size and free from holes.

Size	1" x 1½"	1½" x 1¾"	1⅝" x 2"
Aver. No. per Pound	8	4.2	2.5
Price per Pound	.20	.20	.20

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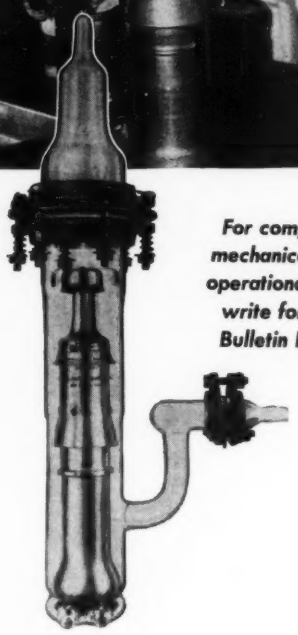

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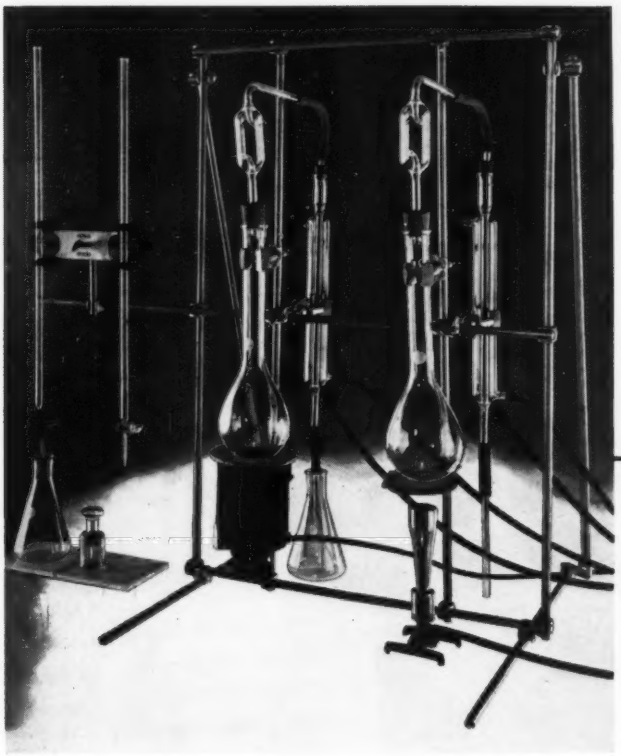

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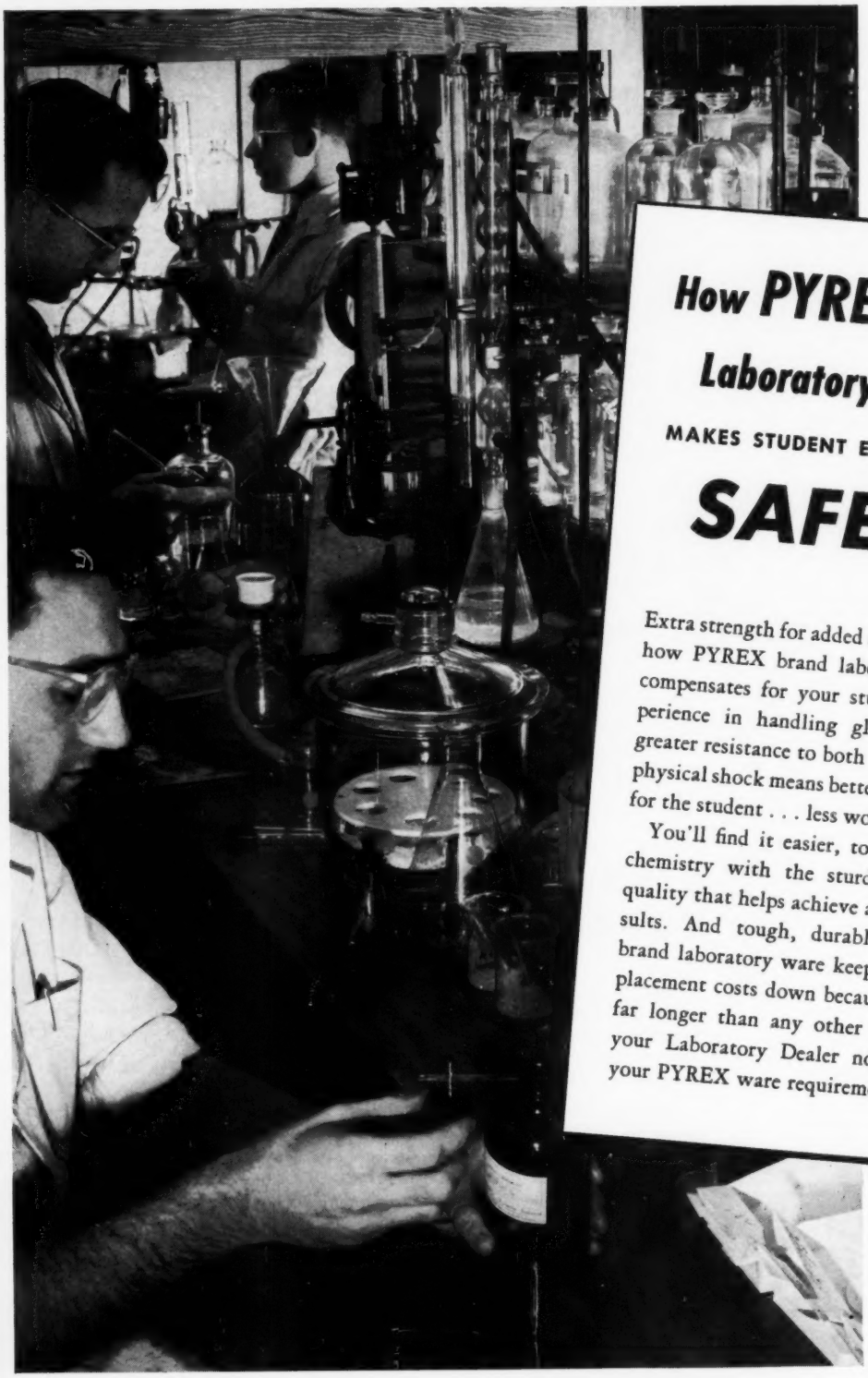

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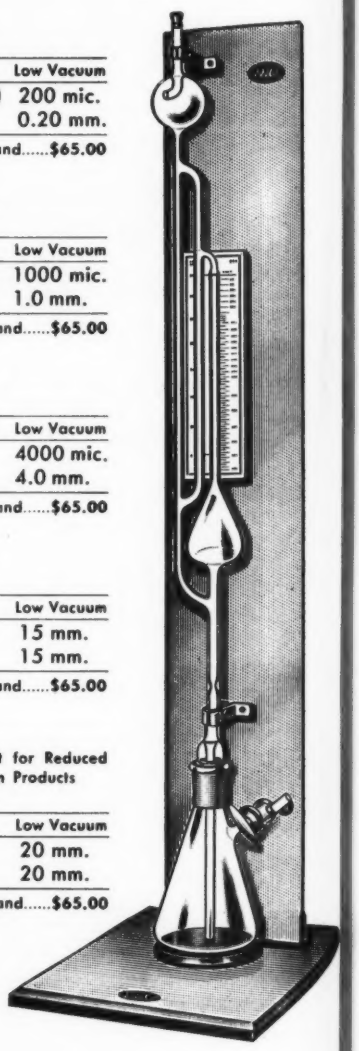

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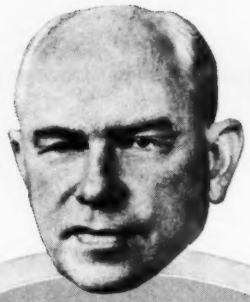

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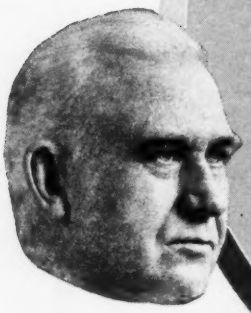

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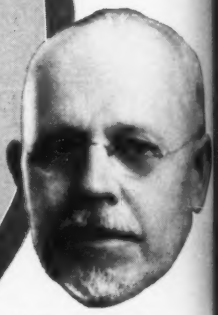

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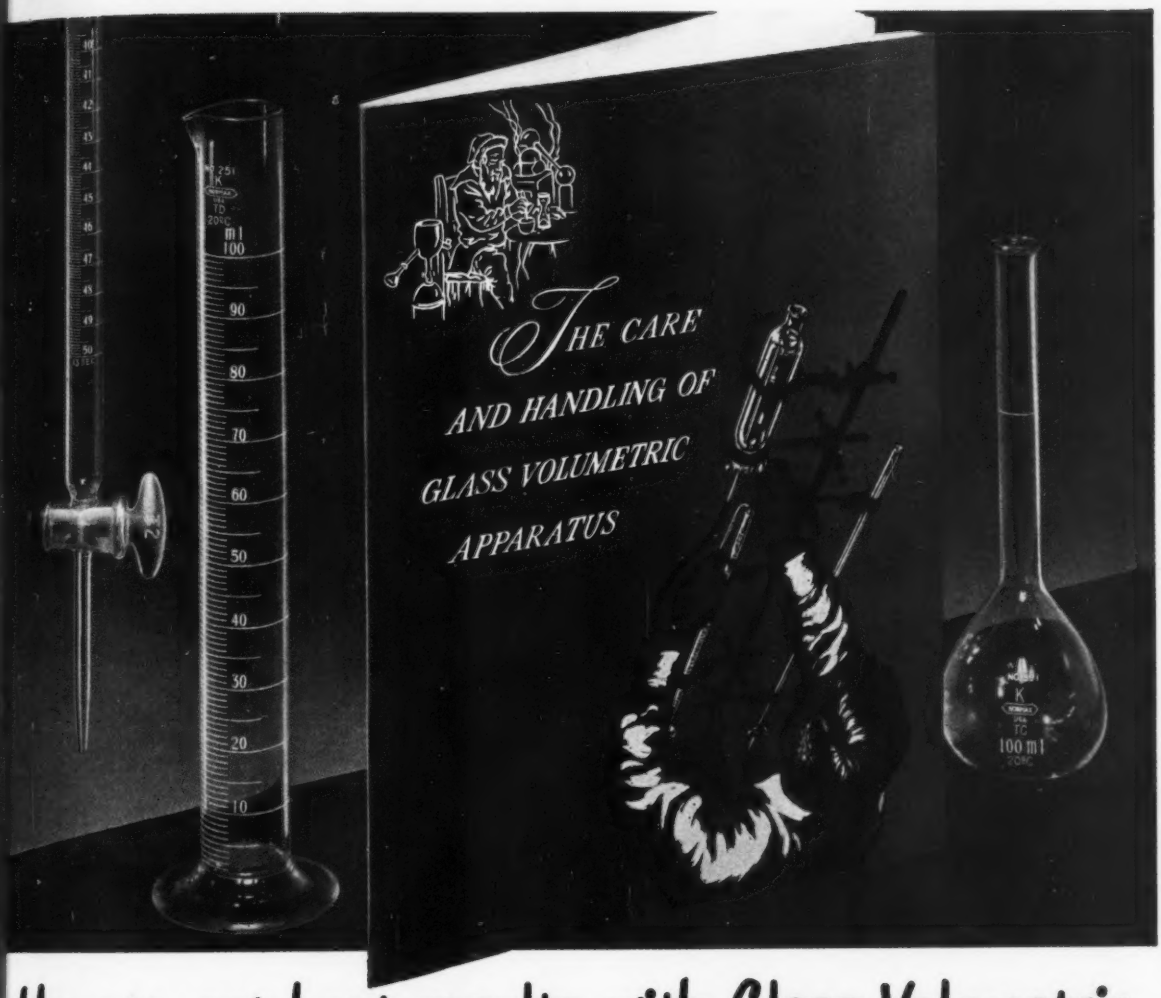

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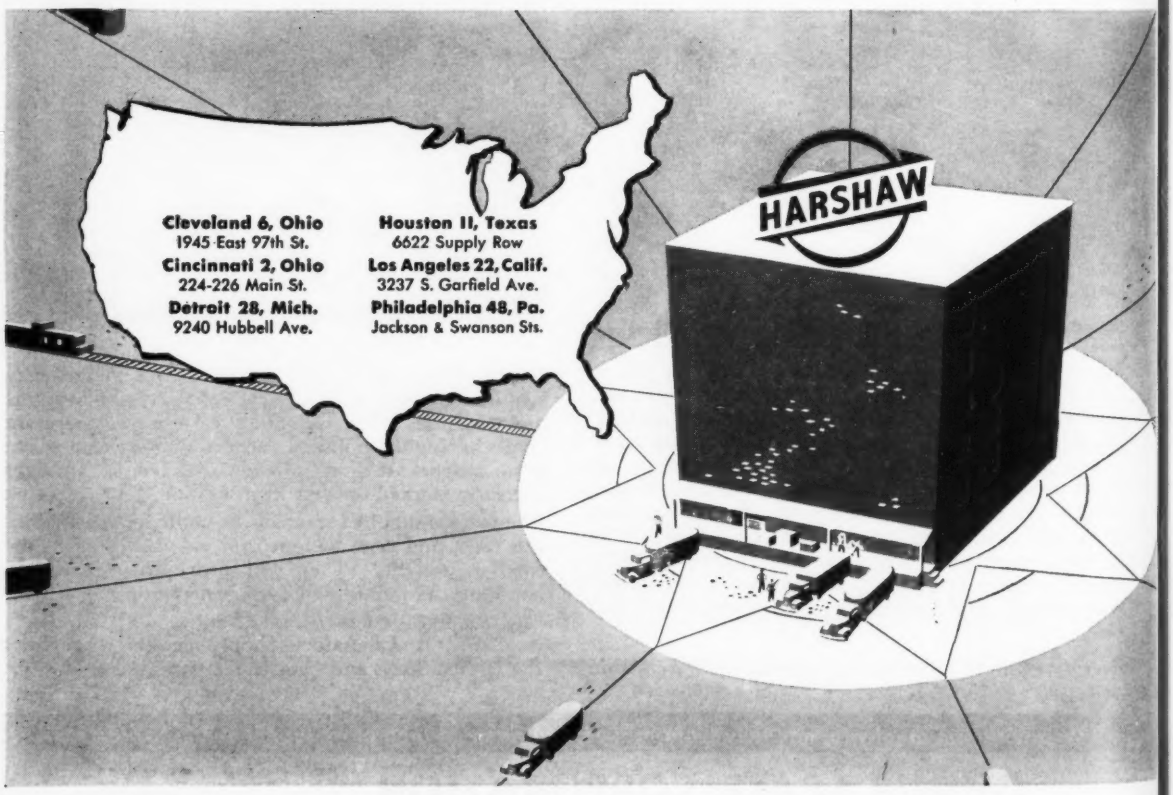

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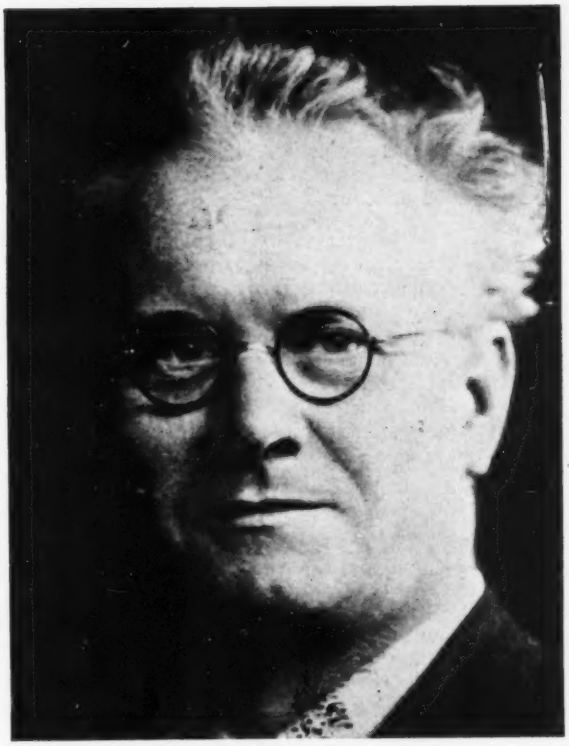

Johan Arvid Hedvall

(See page 381)

Welch

STANDARD MERCURIAL BAROMETER

U. S. Weather Bureau Type

No. 1218.

This barometer is of the standard mercury well, or Fortin, type, which is the type used in the United States Weather Bureau, and other laboratories for observations of the highest accuracy. It consists of a 6-mm heavy-walled glass tube, vacuum-filled with mercury, placed open end down in a cistern of mercury. The tube and cistern are supported and protected by a brass tube in which two long slits have been cut near the upper end so as to show the top of the mercury column within the lower and upper limits of the scale (61 to 81.3 cm). Fastened to the shell alongside the slits are metric and English scales with vernier plates, which are operated up and down by a rack and pinion. The metric reads to .05 mm while the inch vernier reads to .002 inch.

The portion of the casing opposite the cistern has a larger diameter than the upper part and has also a glass window at the mercury level, so that a setting of the mercury surface may be made by a thumb screw pushing against the flexible bottom of the cistern, thus raising or lowering the mercury in the cistern until it just touches the ivory point, which is the zero of the scale. This zero point is permanently fixed to the ceiling of the cistern casing and has, of course, been accurately located so as to fit the interval between 0 and the first graduation on the scale mounted on the upper casing, that is, at 61 cm. The ranges of the scales (61 to 81.3 cm and 24 to 32.7 inches) make the barometer available for elevations of approximately 6000 ft. and for points approximately 1500 ft. below sea level.

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1515 Sedgwick Street Dept. D Chicago, Illinois, U.S.A.

Editor's Outlook

THERE is no denying that the critical manpower shortage has become one of education's most pressing problems. It is pointed up, particularly, in the controversy over the policy of Selective Service. Out of all the discussion that has gone on a few points seem to have become clearly evident.

1. The emergency in which we now find ourselves will probably last for a considerable time. Whether or not actual war breaks out the country must develop and maintain its tactical and strategic defenses for an indefinite period. International responsibilities have been forced upon us which make it impossible to continue our traditional complacent, isolationist attitude.

2. If we are to survive under these new conditions we must maintain our technological and industrial superiority. Military strength is necessary and must be taken for granted, but in this we have some hope of help from allies.

These facts must not be lost sight of, no matter where the subsequent arguments lead.

It is just as true, but not so generally evident, that we cannot afford to interfere with the advance of "pure science" if we are to continue our technological progress; also, that to advance in either of these fields we must constantly recruit new personnel. Urgent reports have appeared lately, such as the one from the Engineering Manpower Commission of the Engineers Joint Council, showing that the number of new engineers in training is dropping at an alarming rate; in view of this fact the supply, in the foreseeable future, will not even begin to fill the demand. The category of "engineers" might just as well be enlarged to include chemists, physicists, and other trained workers in technology and pure science.

I venture to guess that it would be possible to pick out one thousand men (perhaps even fewer) whose sudden and irreplaceable loss from our scientific laboratories would be the difference between survival and eventual defeat in the war which threatens. The value of scientific high-level brains is as vital as that.

Of course, all this is the old question of occupational deferment. It has been told repeatedly, in greater detail and more forcefully. Without raising the issue of class deferments in the Selective Service Act itself, one can certainly argue that individual cases of industrial and technological workers are as urgent as those of farm laborers and theological students.

But the issue is becoming slightly fogged by the clamor over the recent Presidential order to Selective Service. This recognizes the importance to the welfare of the nation of higher education in other fields than science and technology and authorizes the deferment of other successful students in colleges and universities until they complete their curricula—even to graduate degrees. What local boards will choose to do about this "authorization" is anybody's guess.

Most of us on "the inside" of higher education think this is a wise long-term policy, at least while the military needs are not too urgent. Nevertheless, there are understandable viewpoints from which this policy can be criticized. An excellent summary of this issue appeared in the April number of *Platform*, issued by the club and educational bureaus of *Newsweek*.

It has been objected that the provisions are too broad; that it might be reasonable to defer a relatively few, outstanding students, but the standards are set too low and provide for many more than necessary for future "leadership." In principle, there is some sense in this, but it should be remembered that the military, too, like Nature, is very prodigal in providing for its future. Out of a large number of initial recruits only a small proportion actually see combat. (It is said that the percentage is very much higher in the Russian forces.) A Congressional investigating committee recently reported that in the Air Forces alone there was a sufficient number of chair-borne and "boondoggling" officers and men, and others who could be replaced by women and noncombatants, very nearly to fulfill our military commitment to forces in Europe. Let's use our manpower effectively, in all posts.

Be all this as it may, it would be unfortunate—even calamitous— if we should become so separated by the argument over Selective Service and college students in general that we lose our agreement about the necessity for continued training in science and technology and for a concerted effort to increase the number of students in these fields. *This much must be provided for at all costs.*

EUROPEAN CHEMICAL INDUSTRY IN THE NINETEENTH CENTURY

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ANNUAL chemical production of the world has reached a prodigious total of the order of $30 billion. United States output alone, which undoubtedly outstrips that of any other nation, amounts to about $15 billion. These figures immediately suggest that so productive an industry—in reality a group of industries—must have had behind it an impressive story of growth and accomplishment. It is the aim of this article to report on certain phases of the beginning and rise of industrial chemical development in its European cradle, particularly in England, Germany, and France.

The Industrial Revolution of a century and a half ago shook the masses of humanity from the lethargy of medieval primitiveness. In so doing, it was bound to create a most profound stimulus to growth of the chemical industry since the simple fact is that the chemical industry is basic to practically all other industries: There can be no economic progress without the sustenance of chemistry and chemicals. This revolution asserted itself in England between 1770 and 1825 and in continental Europe subsequent to 1815, after Napoleon's downfall provided a measure of tranquility conducive to the development of peaceful arts. From this period on we find a series of significant events and accomplishments which accelerated the tempo of chemical activity, culminating in the present multi-billion-dollar position.

GREAT BRITAIN

Understandably, from what has just been said, a recognizable chemical industry first took shape in Britain. That country, commercially minded more than others, had need for chemicals to maintain, among other elements in its economy, the budding textile industry. A world-wide demand for the cotton goods of northern England and Scotland provided fertile soil for marketing the numerous chemicals that go into a finished textile fabric. Once having initiated plant for some of the major basic chemicals, Britain acquired momentum enough to overshadow all other countries in the output and vigor of its chemical industries. This ascendancy, however, was not to last, for events stirring on the Continent soon after the middle of the nineteenth century shifted the center of gravity of chemical production away from the detached isle and planted the banner firmly in German hands. It takes two to make a bargain, and similarly it was not only Germany's progress but Britain's weakness that contributed to the changed pattern. Specific causes will be brought out hereafter. In like manner, France, although having lit the way in the seventeenth and early eighteenth centuries with a succession of brilliant scientists who contributed greatly to chemical knowledge, failed to convert that knowledge into practical or commercial chemistry on a scale realized by sister countries. Conditions in France differed from those in Britain and Germany, notably by lack of basic raw materials, and therefore the relatively poorer showing made by the industry there is quite understandable.

What were the peculiar conditions that created in Britain by mid-nineteenth century the principal home of the chemical industry?

1. Abundant coal—of a type suitable for production of coal-tar.
2. Extensive salt deposits.
3. Availability of pyrite—all these basic raw materials in fortunate proximity.
4. Ready access to tidewater.
5. A thriving textile industry, with its demand for chemicals.
6. A practical, business-minded people already versed in trade, domestic and foreign.
7. Political stability, with its benign influence on industry and commerce.
8. An empire in the making and therefore favored markets on a huge scale.

This combination had the necessary elements for success; when we add to it the scientific and technical knowledge then available and yearning for exploitation we find added reason for achievement. Furthermore, that bane of infant industries—foreign competition—did not yet stand in the way. This last circumstance, however, allowed only a temporary advantage and in

* A symposium presented at the 118th Meeting of the American Chemical Society, Chicago, September 5, 1950.

fact ultimately proved detrimental, as British chemical industrialists, softened by easy prosperity, succumbed later to the tight pressure put on them by the Germans and, to the surprise of the Germans themselves, the closing decades of the nineteenth century brought a reversal in leadership of the chemical industry. Bringing the picture closer to date we note that in the twentieth century leadership changed again, passing across the Atlantic where it rests by a comfortable margin in our own country.

It is appropriate to introduce a historical review of the chemical industry with a word about sulfuric acid since this chemical is almost as commonplace in the industry and as necessary as water. Known to the alchemists of the sixteenth century, and earlier in the Middle Ages, sulfuric acid remained a costly material until its preparation in lead chambers was introduced by Roebuck and Garbett of Birmingham in 1746. It became known as "English" sulfuric acid. With this chemical available in commercial quantities chemical industrial development was on its way.

Possibly two developments took place in Britain in the early days of the industry that were exceedingly important: invention of bleaching powder, and Leblanc soda manufacture. Charles Tennant, a Glasgow merchant, was already using a solution of chloride of lime in 1788 for bleaching cotton cloth. The time required for this operation thereby shrank from months by the sun to a few hours by means of a chemical. He then developed a solid bleaching material, patented in 1799, made by passing chlorine gas over dry slaked lime which he called "bleaching powder." This was a revolutionizing product; soon bleaching powder became a leading industrial chemical. What is especially noteworthy is that the product created a demand for cheap chlorine which came to be satisfied by recovery from the Leblanc soda process. Tennant's output of bleaching powder in 1799 amounted to 52 tons, worth £140 per ton. By 1805 production had trebled and the price fell to £112 per ton. By 1820 annual production was 330 tons and the price had further dropped to £60. A thriving export business developed, with the United States as one of the principal buyers.

The name of Nicolas Leblanc stands out in industrial chemistry as a landmark. Through his process the world completely satisfied its ravenous need for soda ash and surrendered interest in barilla (natural sodium carbonate). Although France produced Leblanc, the unrequited inventor who died poor and unknown, it fell to others to turn the invention to good account. A heavy tax on salt (£30 per ton) was lifted by the British government in 1823; this action paved the way for the Leblanc process to come into wide vogue in Britain after unsuccessful operation in France. James Muspratt, an Irishman, built a Leblanc plant at Liverpool in 1823. Other plants soon followed, one of these being located at nearby Widnes on the Mersey River by John Hutchinson, who, only 25 years old and with but a few month's experience, had 100 men working within a year. The day of reliance on natural soda was over and Britain with its manufactured product not only supplied itself but became the world supplier.

England is recognized as the home of the aniline dye industry. William Henry Perkin in his quest for a synthesis of quinine accidentally came upon the dye mauve in 1856. For the next quarter of a century the synthetic dye industry flourished in England. Under the title of Perkin & Sons, the scientist Perkin began making dyes the year after his discovery. Read Holliday of Huddersfield in 1860 began making magenta, nitrobenzene, aniline, and toluidine. Roberts, Dale and Co. of Manchester also started production of aniline in 1860. One or two other English firms were attracted at about the same time to manufacture of the intermediates as well as the dyes themselves. In 1864 Ivan Levinstein founded his well-known dye-manufacturing firm at Manchester and subsequently became the leading figure in Britain's fight to maintain the industry. On the Continent, French and German organizations rose to the opportunity in dyes. At Lyon, France, Renard Freres commenced in 1859. The Badische Anilin Co. erected a works at Ludwigshafen in 1863 and in two years had 60 employees, thereafter to become the world's dominant dye firm.

Scientists of the day recognized the original leadership in dyes that lay in British minds and hands. As a result they were attracted from other lands, principally Germany, to British plants where they contributed to the discovery of many new dyes. The influx of foreign chemists, however, came deliberately to absorb what it could and then take the knowledge back to the homeland, or perhaps did not find conditions conducive to a permanent connection. At any rate, a goodly representation of the great dye chemists of the era packed up after only limited stays in England, returned to Germany, and there applied themselves to the glory of their native land. Thus, Hofmann returned in 1865, Caro in 1867, Martius about 1870, Witt in 1879. Coincident therewith some of the British dye firms, especially those of professorial antecedents, chose to suspend operations. Perkin retired in 1874, Nicholson in 1868, and Greville Williams in 1877. What had once been a company of brilliant research workers under the aegis of English industry dwindled to an ineffective handful. From that period on—until World War I compelled a revival—the sun set on British aspirations in the coal-tar dye field. It is said that had the nation been far-seeing and wise, the industry could have flourished for longer than a quarter of a century. But unfavorable conditions within England, coupled with a vital upsurge in Germany, brought about the English defection.

One of the weaknesses in Britain was the absence of a high-grade school of organic chemistry which could have provided a flow of trained personnel for dye research. Chemical education 150 years ago was anything but the organized system of today. At the beginning of the nineteenth century the great Swedish chemist, Berzelius, was the outstanding teacher. Another prominent personality was Gay-Lussac, noted French

scholar who taught Liebig and Bunsen. Justus von Liebig, a man of imagination, originality, and sound thinking, proceeded to establish in Germany the world's leading school of organic chemistry. A dynasty of expert chemists grew up around him and these in turn trained younger groups.

It has been mentioned that Britain was a large producer of coal tar, a product of its coking industry. Much of this prior to about 1890 was exported to Germany, which produced only a meager supply of its own. The Germans, with their acquired knowledge, skill, and facilities, transformed the tar into finished products, consisting at first largely of dyes but later pharmaceuticals and photographic chemicals also, and sold these to England. Ultimately, coal tar flowed freely from coking works of the mighty German steel industry; England was left virtually without a market for coal tar and furthermore without much of a coal tar dye industry.

In 1878 Adolf von Bayer, discoverer of synthetic indigo, said:

> Germany, which in comparison with England and France possesses such great disadvantages with reference to natural resources, has succeeded by means of her intellectual activity in wresting from both countries a source of national wealth. Germany no longer has to pay tribute to foreign nations but is receiving such tribute from them, and the primary source from which this wealth originates has its home, not in Germany, but in England. It is one of the most singular phenomena in the domain of industrial chemistry that the chief industrial nation, and the most practical people in the world, have been beaten in the endeavor to turn to profitable account the coal tar which it possesses. The numerous German color works purchase from England the greater portion of the products of the distillation of coal tar, and they supply three-fourths of the world with the colors made from it. However, we must not rest on our laurels for we may be sure that England, which at present looks on quietly while we purchase her tar and convert it into colors, selling them to foreign nations at high prices, will unhesitatingly cut off the source of supply as soon as all the technical difficulties have been surmounted by German manufacturers.

Speaking eight years later, the English dyemaker, Ivan Levinstein, lamented that England had not cut off coal tar from Germany, that England was still supplying three-fourths of German requirements, while allowing Germany to supply it with at least three-fourths of the dyes used in England. Levinstein pointed out that industrial development in England for the preceding third of a century had been concentrated in cotton, wool, coal, and iron, to the neglect of other industries, including the chemical. Fortunes had been easy to come by in these staples over the years and the British mind centered on them. The general public was in profound ignorance of industrial chemistry and its importance, hence the want of enterprise in that direction. In England men of science mingled neither with the business community nor the lay public. In Germany the situation was quite different: There was no superabundance of accumulated wealth, nor easy opportunities of acquiring it; the great natural advantages did not exist; chemical knowledge was more diffused among the people, consequently new branches of chemical industry were eagerly sought for and exploited with the support of the people, the scientists, and the capitalists. While England had eminent engineers, it was short of chemical engineers, without an adequate supply of whom there could be no successful industry. The Germans made it a point to train large numbers of chemical engineers, thoroughly competent in the design and operation of chemical plants. These plants were often in association with engineering and machine shops which made the specialized equipment needed and which could produce apparatus of better or cheaper construction than was obtainable in England. Levinstein argued forcefully with the instinct of a prophet that the salvation of his country's industry required the scrapping of numerous uneconomic Leblanc soda plants in favor of ammonia-soda works for which cheap salt, cheap ammonia, cheap coal, and cheap capital were at hand. Also, pointing to the high price of sulfuric acid in England relative to Germany, he declared that if the acid makers would not remodel their plants or alter their process the consumers should band together to erect their own modern works.

The British suffered from other disabilities. Their patent laws enabled a foreigner to take out patents without working them in England. Thereby, the Germans, Caro, Graebe, and Liebermann, with an English patent on alizarin, squeezed Perkin out of the coveted prize—by just one day. Perkin thereupon had to remain content with a license from the Germans. This situation was not rectified until passage of the Patent Law Amendment Act of 1907. This Act obliged foreign patentees to operate their British patents in Britain or to license others. It resulted in forcing German firms to build dye and intermediate works in England. The British, with their concept of free trade, allowed foreign dyes to come in freely whereas British dyes were heavily taxed if they entered Germany. This policy played directly into the hands of their competitors. The British government found it necessary to impose a high excise tax on industrial alcohol, which was required in large volume for making dyes, particularly of the basic type. The high internal tax, along with stringent regulations, ran the cost of production so high that in some cases the cost of the alcohol alone equaled the cost of the dye itself in Germany. Inevitably, the manufacture of basic dyes had to be abandoned. Later, in 1891 and 1902, the patent regulations were modified but the harm had already been done.

In the matter of scientific journals, the Germans showed their progressiveness with half a dozen publications before the English had one. The *Journal of the Society of Chemical Industry* was not published until 1881. This journal, however, became outstanding in its field; it developed into a bulwark and mainstay of the industry, accomplishing much in restoring Britain to the high chemical eminence of the present day.

GERMANY

The Industrial Revolution came to Germany late and made slow progress up to about 1865. Industrial backwardness in that country paralleled its reactionary politics. In 1834, a protective customs union known as the *Zollverein* was established among the various German states and stimulated somewhat commercial development. Political consolidation in 1871 into the Empire sparked the meteoric rise of Germany to become the greatest industrial power in Europe. Chemistry was one of the principal factors through which Germany's economy rose to power.

Even during the quiescent period in the first half of the nineteenth century, the basis of German progress was laid in superior education. "Chemical knowledge in its various branches is further advanced than with us," admitted a prominent Briton in 1840. During that period, Liebig the great teacher, revolutionized the thinking of chemists. It was he who suggested the addition of chemicals to the soil to restore fertility and thereby started off the fertilizer industry. He showed that bones, after treatment with sulfuric acid, could contribute their phosphorus to plants. The commercialization of this idea however first took place in England when John Bennet Lawes in 1843 established large works near London to make calcium superphosphate.

The famous potash deposits of Stassfurt began to be worked systematically only in 1860. Discovered accidentally in 1857 while boring for rock salt, they possibly proved more valuable to Germany than their equivalent worth in gold. Output in 1861 was 2,000 tons; 50 years later, 11 million tons. Other natural resources include ordinary salt, pyrites, and coal. Once the inaction of pre-Empire years was sloughed off, these raw materials, as in Britain, put the Germans on a firm basis chemical-wise. The late start was not altogether a disadvantage for Germany proceeded to profit from the latest techniques and equipment. She took hold of the superior ammonia-soda process while the British clung to the outmoded Leblanc process. The price of basic chemicals was brought down to less in Germany than in England. While raw materials were cheaper in England the end products cost less in Germany. For more than half a century England ruled the markets of the world in caustic soda, but the time came when the home market was invaded by the German product and even gave preference to it. On soda ash in 1886 there was a 15 per cent price advantage in Germany; on sulfuric acid, 34 per cent.

The Germans early recognized that the chemical industry was an important asset in their economy. They also recognized that the British had forged ahead in this field and it was therefore to their (the Germans') advantage to learn from the experienced British. They copied English equipment and methods; they sought employment with British firms, willing to work at low pay to acquire insight into the fundamentals of the business. English machines were brought to the testing shops in Berlin where they were tried. If successful, a working model was made for the museum while the original was presented to a progressive manufacturer.

The character of the German people differs from that of Britons and Frenchmen, according to a British authority, who goes on to say that it is peculiarly adapted to succeed in an industry such as the chemical, where patience and methodical procedure pay off in large rewards. Another source says that above all must be reckoned the basically high mental caliber of the people, with their especial aptitude for material things. "Every man is intelligent and every man thinks" was a British estimate in 1840 of the Prussians. The most impressive case of Germany's rise to leadership is in connection with the dye industry, for the development of which the German temperament seems peculiarly adapted.

FRANCE

France early produced distinguished chemists who brought that country to the forefront as a center of chemical thought. Not only was theoretical chemistry advanced but the industrial side as well. The first French sulfuric acid plant of industrial caliber was erected in 1766. The Revolutionary and Napoleonic governments fostered the policy of state help to industry, at the same time allowing all possible freedom in its affairs. Leblanc's soda ash process, instituted in 1792, had the active encouragement of the French Committee of Public Safety. By 1830, 20 Leblanc plants were producing 30,000 tons of soda ash. The beet-sugar industry developed under governmental support. This industry, even in competition with imported cane sugar after the lifting of the blockade, did so well that by 1836 the annual output of some 400 small factories reached 40,000 tons. Improvements followed in sugar technology, notably through introduction of triple-effect evaporators in 1852; production in 1875 exceeded 450,000 tons.

France pioneered in other directions. Gas for illumination was first tried at Paris in 1815. An India-rubber industry came into being before 1848 and by 1845 the daguerreotype photographic process was a going operation in Paris. The chemistry of fats was explored and the results revolutionized the soap and candle trades. France has always been noted as a perfume center. Think of a per capita consumption of 4 quarts annually in recent times to realize the significance of perfumery there.

But the early promise of French chemistry failed to follow through industrially with the vigor shown by Britain and Germany. For one thing, education was not organized adequately to provide the flow of engineers and technologists needed for large-scale industry; this, in sharp contrast to Germany. The natural resources of France, as of 100 years ago, compared unfavorably with those of rival countries. There was salt in the east and in the southwest but no coal nearby. What coal there was came at a relatively high price, with consequent handicap to the competitive position

of a coal-tar chemical industry. Confronted with a relative dearth of raw materials and the burden of extra transportation costs to acquire them, the French chemical industry was obliged to trudge along as a third-rate entity. As in the case of Britain, the French position in chemicals, generally speaking, remained retarded until the break with Germany in 1914 forced a broad internal development. From then on, progress in chemical manufacture has measured up to the demands of a modern, industrial state.

CONCLUSION

Britain, France, and Germany had an equal chance in the early years of the nineteenth century to establish chemical industries. Chemical science of that period was ripe for industrial development. Britain first took the lead from a combination of favorable circumstances, with France relatively backward and Germany preparing for ultimate primacy. The British people and government failed to appraise chemical industry for the importance it wields in national and international affairs and allowed its industry to drift. Simultaneously the Germans, alert to the possibilities and well adapted to chemical research, forged ahead and became the world's leading chemical power. As the chemical history of the century is examined it is evident that natural resources, proximity of raw materials, national characteristics, ability, foresight, and liberal governmental attitudes, all played important roles in advancing the world chemical industry.

DUMAS, DAVY, AND LIEBIG

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At the beginning of the nineteenth century French chemists occupied leading positions in practically every one of the then recognized branches of their science. In Paris were found the men whose theories were taught everywhere, and whose experiments were models imitated in all other countries where chemistry was studied. England and Germany also possessed active investigators, but neither ranked with France as a chemical center. By the end of this same century the position was completely reversed. Leadership had passed to Germany, and France had dropped behind England in chemical activity. The reasons for this change were complex and certainly involved economic and social factors which would require a detailed analysis for full evaluation. However, some idea of the causes behind the change may be obtained by a study of the lives and thought of the chief chemists of each country.

Science in the early nineteenth century was far more international than it is today. Even during the Napoleonic wars between England and France it was possible for Humphry Davy to visit Paris as an honored guest, transported by a government ship. The contacts between scientists of different countries were limited only by difficulties of travel. It is therefore dangerous to generalize too freely from the activities of single chemists. Individuals should not be considered as typifying national traits. Nevertheless, the chemists of each nation were molded by the particular culture of that nation and by the political and social forces which acted upon them, and so to some extent it is possible to see in their behavior a reflection of the national characteristics upon which the scientific position of their countries rests. It is therefore of interest to consider outstanding chemists of the three nations—France, England, and Germany—in order to see them as representatives of the chemical science of their countries. An analysis of this science in general terms will indicate how closely the men chosen for study conform to the national pattern.

The leadership of the French chemists as the nineteenth century began was firmly based on the work of Lavoisier and the brilliant group of investigators who surrounded him. Prior to their time chemists had accumulated a great array of facts, but these facts lacked systematization. The phlogiston theory, which superficially appeared to explain them, was vulnerable to any truly scientific study, and fell quickly when Lavoisier made such a study. His method was an outstanding example of logical generalization, at which the French chemists have excelled. In lesser degree his contemporaries, Guyton de Morveau, Berthollet, and others showed this same generalizing power, and this not only gave chemistry its modern foundation, but also gave to France a place of leadership in chemistry. The position was maintained by another peculiarity in the organization of French science. French chemists

worked as individuals. They studied chemistry not in large institutions, but in a close master-pupil relationship, and once this bond was dissolved, each participant went his own way. They could cooperate with one another when it seemed desirable, but there was seldom a formal connection between them. This loose organization permitted French chemistry to survive the French Revolution almost untouched, even by the death of Lavoisier. The new generation of French chemists continued the work of their predecessors almost without a pause, for their private activities had not been affected by the great political changes going on around them. The extreme political centralization of the Napoleonic era was, however, reflected in an intense scientific centralization in Paris, and for a time, at least, this probably aided the progress of chemistry.

English chemists were even more individualistic than the French. They approached chemistry in the spirit of amateurs. Their special genius lay in experiment rather than generalization. Priestley and Cavendish added significantly to the knowledge of facts, but they made few attempts at organization of these facts and even preferred to reject the new theories produced in France. Even Dalton, who did make a major generalization, limited himself by a number of rigid assumptions which left the development of the full consequences of his theory to continental chemists such as Gay-Lussac and Avogadro.

The Germans were divided, politically and scientifically. Their chemists, working in small provincial capitals, often did their best work in private pharmacies, and, if they were at length appointed to university chairs, were no longer scientifically active. They tended to devote themselves to problems of mineralogical and analytical chemistry, and although they could generalize they used this power rather to organize systems of minerals or methods of analysis than to produce major theories of chemistry. Klaproth is an outstanding example of these chemists.

Among the chemists of the generation which followed the associates of Lavoisier one of the most brilliant was Jean Baptiste André Dumas (1800–84). His work belongs to the first half of the century, for after 1848 he was more concerned with administration and political activity than with chemical research. He showed to a high degree the ability for logical generalization which has been indicated as a typical French trait. His important contributions to the theories of radicals, substitution, and types reflect this power. Yet his life also illustrates other factors which were of great significance in the later history of French chemistry.

He began his career through the influence of Alexander von Humboldt, who introduced him to the scientific circles of Paris where all French chemistry centered. The powerful position of his sponsor opened to him doors which would otherwise have been closed and permitted him to establish himself and his reputation on a firm basis. As a result, he soon held a considerable number of academic positions simultaneously. He lectured at the École Polytechnique, the École de Médecine, and the Collège de France, and he established his own teaching laboratory for the instruction of young chemists. Yet with all this he never became identified as the founder or director of a school of chemistry. When his political activities began to take most of his time he gave up his teaching laboratory entirely.

He was a very influential member of the Academy of Science and eventually became almost the dictator of chemistry in Paris. Since almost no chemistry existed outside of Paris, so far as France was concerned, he was able to grant or withhold favors at will. Those in his friendship held the important academic posts, one man often holding several, as Dumas himself had done. Other who, like Gerhardt, incurred his enmity were never able to obtain a position in Paris, and had to remain in small, provincial universities where they were without recognition or influence. The extreme centralization of French chemistry fostered the growth of such power, and the Academy of Science became the arbiter of the destinies of French chemists. It was dominated by conservatives, and it is very probable that this control was one of the most influential factors in the decline of French chemistry. The individualism of French chemists, which had previously been a source of strength, now became a drawback, since it prevented any organized attempt to overthrow the power of the Academy.

During the latter part of the century, the great men who appear in French chemistry stand as isolated figures. The centralization of the science and the lack of numerous research organizations for training young chemists resulted in failure to produce men to staff chemical industries. By the dawn of the twentieth century it had become clear that chemical predominance resulted from the interaction of academic and industrial research. The very factors which produced French leadership in the eighteenth century thus led to its decline in the nineteenth.

Humphry Davy (1778–1829) may be chosen to exemplify the English chemist of this period. Although he was not an amateur in chemistry, as Priestley and Cavendish had been, his approach to the science was essentially that of the amateur. He was practically self-taught. A brilliant experimenter, his studies of the alkali metals and chlorine helped to clear up many faulty points in the theory of Lavoisier, although they did not lead to any completely new theory themselves. Davy carried on his work purely because of its interest for him, and when, in later life he made a wealthy marriage and became interested in a society career he virtually abandoned chemistry. This attitude of working on a problem because of its intrinsic interest to the experimenter rather than out of a sense of advancing the progress of chemistry is essentially that of the amateur, and it is characteristic of the English chemist. The tendency to disregard the opinions of the outer world has led to a degree of stability which is also characteristic of English science. Work proceeds at an even rate and the output does not vary with bursts of interest in newly fashionable branches of science. It also results

in continuation of study in fields which may tend to be neglected as newer fields become popular. Davy worked almost entirely in inorganic chemistry, and English chemists continued to study this branch even when continental chemists were devoting all their time to organic compounds.

As a result of this approach to chemistry, no such centralization of authority arose in England as it had in France. Wherever an outstanding chemist happened to work was an important laboratory while he worked there, but once he stopped, it lost importance. The Royal Institution was created as a chemical center by Davy, and Faraday continued to work there, but after the death of the latter it declined in importance and was replaced by other laboratories. The major reason for this was that the English, like the French, did not create schools of chemistry. Therefore England, too, lacked a large group of competent chemists to staff research laboratories when chemical industries began to appear. However, the innate stability of English chemistry kept it on an even base while the chemical activity of France declined under these conditions.

Justus von Liebig (1803–73) devoted most of his productive early life to organic chemistry, and contributed largely to the theory of radicals and organic structure. Like Dumas, he became a leader of chemical thought, but for very different reasons and in a very different way. In Germany, as in England, no great center dominated the chemistry of the country. Research began to be concentrated rather in the various provincial universities. The chemists in these institutions were professionals in every sense. Although the reputation of any one university usually depended initially on the presence in it of an exceptionally gifted scientist, his work often survived his departure, and the university authorities attempted to replace him by an equally able professor. There was thus a continuity which was not found in England. In addition, the universities served as training centers for producing large groups of young chemists. It was in this field that Liebig was most influential, and he set the pattern which was typical of German chemistry throughout the century. His experimental work and his writings made him internationally known, but his teaching laboratory in Giessen was far more important than either of these. The chemists who received training in research under Liebig and his successors were equipped not only for an academic career but were also ready to enter industrial laboratories and so to establish the great chemical industries which played so large a part in the advance of German chemistry.

The whole attitude of the German universities was opposed to the centralized French system. Liebig himself expressed this difference in a letter which he sent to a former student, Gerhardt, who was attempting to establish himself in Paris. He wrote:[1]

> Your new theory of substitution has caused me lively anxiety on your behalf; it is clever, comprehensive, and contains good observations, but it is a ladder without rungs for you; it does not help your advancement. Believe my experience: for theories there is no more dangerous soil than France. Nothing injured Dumas at the beginning more than his preponderant inclination to theories. The Academy has always claimed for itself the right to draw up the laws of science, and it regards everyone who does this in its place *as a thief and a robber*. A young man who wishes to force, or does force, the old gentlemen to teach according to his own laws may no more hope for the slightest advancement. Such young men always believe themselves to be still on neutral German ground, but they are upon ground that contains explosive material of all kinds.

The early years of the nineteenth century were years of development and exploitation of the theories of Lavoisier. There was still room for new theories and generalizations, based on the information already at hand, and in this work the French tradition still enabled its representatives to produce important generalizations. The science of chemistry was, however, growing more and more highly systematized, and the individualistic French, dominated by a centralized authority, did not respond to the increasing need for an organization flexible enough to accommodate new discoveries, yet with sufficient continuity of effort to apply these discoveries in a useful manner.

The English also lacked such organizations. Single investigators, like Graham, produced work of the greatest importance, but it was not related to other work of the period, and many years had to pass before it was fully appreciated. Although the Industrial Revolution began in England it was at this time a mechanical revolution and chemistry played only a small part in it. Hence the practical genius of the English could not express itself in a chemical industry.

The Germans, growing closer politically, were able to overcome the disadvantages of the provincialism which had held them back, yet to develop a number of separate research centers in their universities, whose activities tended to cross-fertilize each other. By training research chemists the universities became research institutes themselves. Thousands of new facts accumulated, and the men in closest contact with these facts were able to propound the theories to explain them. The educational methods developed by Liebig began to bear fruit, and the rise of Germany to chemical leadership proceeded at ever-increasing speed.

[1] GRIMAUX, É., AND C. GERHARDT, "Charles Gerhardt, sa vie, son oeuvre, sa correspondance," Paris, 1900, pp. 42–3.

FARADAY, HOFMANN, AND WURTZ

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THE three great chemists to be considered next were not only the intellectual heirs of the three preceding and extenders of their work and teachings, but also, in their own right, leading thinkers and researchers, and outstanding figures in their respective countries during the middle third of the nineteenth century.

Faraday, much older than the other two men, had little in common with them. The fact that he discovered benzene might seem to be the only bond of common interest. Each in his own way, however, was a great experimenter, an inspired organizer of science, a fascinating lecturer, a popular teacher, and a gifted writer. Hofmann stands as a link between England and Germany, because he worked in both countries; and between Germany and France, through his long personal and professional association with Wurtz. Both had been students of Liebig; both were successful university teachers; and both were leaders of research in organic chemistry, fully conscious of the potential influence of chemistry on the industry and economic welfare of the world.

An odd but interesting composite snapshot of the state of science in general, and chemistry in particular, in the three leading countries of Europe at the beginning of the period under discussion is to be found in "Reflections on the Decline of Science of England," published in 1830. It is principally an elaborate criticism of the Royal Society, but the author, Charles Babbage, marshals many facts and quotations to support his own view that science was then esteemed more highly in Germany and France than it was in England. Reviewing the impressive international congress of natural philosophers, which had been held in Berlin in 1828, the author declares that the highest respect for science in government circles was evident in Germany (meaning Prussia); and that Germany was advancing rapidly because all English and French discoveries and publications were at once seized and translated. France, recovering from forty years of upheaval, was trying to review and readjust the heritage of Lavoisier; but its various governments had never failed to reward the work of its eminent scientists by appointment to public office. Only England seemed to be supremely indifferent to science and to the extremely important place it could and should hold in all national development.

In England (still according to Babbage), the pursuit of science was not a distinct profession, as it was in other countries. One could pass into a university from one of the public schools without any kind of useful knowledge. Lack of appreciation and official encouragement seemed to be because the public (*i. e.*, consumers) are better judges than government, when it is a question of the practical value of a scientific or technical contribution; and because any reward from commercial sale would be much larger than the government could bestow. As proof that few positions were open to true scientists, he shows that several well-known persons held many positions. The only chemist mentioned—Brandt—for example, was then Clerk of Irons at the Royal Mint, Professor of Chemistry at the Royal Institution, Editor of the journal of the Royal Institution, analyst of the East India Company, Lecturer on Materia Medica at Apothecaries' Hall, Lecturer on Chemistry at Apothecaries' Hall, Superintendent of Chemical Operations at Apothecaries' Hall, and Foreign Secretary of the Royal Society. From all of this one could gather either that a scientist is paid too little and that, therefore, gentlemen cannot be found who can afford to take only one position; or that the scientist is too well paid—each position requiring so little attention that anyone can handle several.

After exposing everything he considers objectionable about the Royal Society and all its works and pomps, the author also makes sideswipes at twelve other recognized professional societies. All of these elected "Fellows" in various branches of science or natural philosophy, thereby giving these persons the right to hang a "comet's tail" of letters after their names, but actually standing for widely differing degrees of accomplishment in their respective fields.

In fairness it must be said that this publication was answered within a year by someone who signed himself "A Foreigner" (identified as Gerard F. Moll). This pamphlet, with a foreword by Faraday, declared that there was much evidence of good in the English scientific societies, especially in their being supported by relatively large memberships. He rather deprecated the appointment of successful French and German scientists to public office, saying that, at least in Germany, such an appointment always went to a man who was first a qualified noble or aristocrat, and second, a scientist. As for France, he deplored the appointment of scientists whose titles dated from the first Empire, or whose appointments had obviously resulted from a forced change in politics.

So much for background. By 1830–31 Michael Faraday was well established as the leading figure of the Royal Institution in London. The facts of his life (1794–1867) and work are too well known to require more than passing mention here. He was self-educated and, although he became one of the titans of nineteenth century chemistry, he started as a satellite of Davy in physics or natural philosophy. Much of his work was actually physical chemistry, or what came to be called

electrochemistry, but he always preferred to be called a natural philosopher.

The Royal Institution, with which he was associated throughout his professional life, was an offshoot of the Royal Society, founded for the cultivation of more popular and elementary branches of scientific knowledge. It rose to prominence, principally through the interest and activities of Davy, and became known as a center for research on scientific problems—chiefly those involving physics and chemistry. Anything, it seems, could be sent to that laboratory to be identified or analyzed, and it was sure to receive Faraday's personal attention.

In addition to the routine work, Faraday worked on the liquefaction of gases, on butylene, and on compounds of carbon and chlorine. His meticulous notes (1825) on "Liquor from condensed oil sent by Mr. Gordon" show all the mental processes whereby he arrived at what he called *bi-carburet of hydrogen*, later identified as benzene. The progress of this exhaustive research on a new and baffling substance clearly proves his native gifts of intuition and persistence, and his ability both to organize observed facts and to present them in beautiful, lucid exposition.

Faraday was interested in magnetism and electricity from 1820. The entries during the many years devoted to this study and research carefully record all the defeats, disappointments, and repeated starts, and constitute a model procedure, still worthy of emulation by all true researchers. He greatly simplified the study of electricity by proving that however it may be produced it is the same force.

Although Faraday frequently communicated and conferred with others interested in the same work, he was a solitary figure. He was a great teacher, who founded no school; yet he was instrumental in having courses in science introduced into various schools. For several years, during the Christmas holidays, he gave a series of six lectures "before a juvenile auditory"; all of which were attended by capacity crowds. Two of these, "On the Chemical History of a Candle," and "On the Various Forces of Matter" are composite masterpieces of the clear and simple language of which he patiently made himself the master. Each lecture was illustrated by well-planned demonstrations which (according to Crookes, who edited these lectures for publication) never failed. In presenting his book on "Chemical Manipulation," he said that chemistry is necessarily an experimental science with two objectives: proof or demonstration of known facts; extension of present knowledge. Throughout this book, in which he describes all his apparatus and methods, he stresses the great value of being able to work with small quantities.

Faraday tried to be a perfectionist in everything, and he strove constantly to improve his manner of speaking and writing. He was a deeply religious man, a faithful attendant at the services of a rigid nonconformist Scottish sect, and in his manifest dignity and self-respect he practiced the humility of spirit and self-denial that his church demanded.

Although he firmly believed that government should reward the fruits of scientific research by recognition of scientists as a class, Faraday just as firmly declined a title and all other honors that were offered to him. He refused to make money because he felt it would cost him his freedom. As he put it: "Do not many fail because they look rather to the renown to be acquired than to the pure acquisition of knowledge, and the delight which the contented mind has in acquiring it for its own sake?"

To present any list of the industries that have been established through the discoveries of Michael Faraday would be merely "the elucidation of the obvious." His work on electricity was continued by Clerk Maxwell, J. J. Thomson, and others; and its applications in industry go on and on. His early work on butylene led to the knowledge of polymers.

From 1830 until 1845 Faraday was certainly the leading light of science in England. The first teaching laboratory in Great Britain had been established as early as 1817 by Thomas Thomson in Glasgow. In 1837 Thomas Graham transferred his teaching and research from Glasgow to the University of London; but it was still mostly physical and inorganic chemistry. Britishers interested in chemistry were going over to Germany to study with Liebig, and they brought back glowing accounts of new kinds of chemistry and new methods of teaching it. The marriage of the young Queen Victoria to Prince Albert of Saxe-Coburg-Gotha —a devoted amateur scientist—gave added impetus to a growing movement, and finally, in 1842, an intellectual hurricane struck England in the person of the great Liebig himself.

On a personally conducted, *de luxe* tour the famous German chemist lectured everywhere on the need for better knowledge of organic chemistry, particularly agricultural chemistry. His sincerity and eloquence aroused such strong public enthusiasm that it was decided to establish a new school of chemistry in London. Faraday, Graham, Brandt, and many others signed the official petition, and Liebig was asked to recommend one of his own star students to head the new institution. Fresenius and Will having declined the honor, August Wilhelm Hofmann, of Giessen, was finally persuaded by the royal couple to take the position. He went to London in 1845, to take charge of the construction and operation of what was to be called the Royal College of Chemistry.

Hofmann (1818–92) had been one of Liebig's most promising students. Chemistry was an acquired taste for him, as his earlier studies had been in law, the classics, and philology. His earliest research was on aniline, and during his stay in England he laid the foundation for a flourishing industry based on aniline and coal tar. He was an extraordinary teacher and lecturer, popular with every type of audience, from the royal household to the groups of working men to whom he periodically gave talks on science—principally chemistry. In addition to the research in pure science, of which he was a resourceful and inspiring director, he

also tried to inculcate in his students an appreciation of how they could utilize their knowledge of chemistry in many civic occupations.

Among Hofmann's students were Abel, Crookes, Mansfield, E. C. Nicholson, Perkin, and Playfair, all of whom distinguished themselves by their independent researches and accomplishments. Many other students followed Hofmann from Germany—among them Merck, Martius, Caro, and Griess—who either stayed on to assist him in his own research, or took important positions in industry.

Hofmann, himself, had a great gift for friendly association, and he took an active part in all professional activities. For many years he served as foreign secretary of the Royal Chemical Society, sending notes and papers to the French and German scientific periodicals. He assisted the Prince Consort in planning the scientific exhibits for the first great international Exposition of Arts and Industries in 1851; and his report on them gives a splendid cross section of the state of science and industry at that time. By the time of the second exposition, in 1862, the aniline dye industry had been established in England, and Hofmann saw to it that all the best it had to offer was exhibited in full glory. As president of the Chemical Society—his gift of tongues always in practice—he greeted foreign delegates in French, German, and Italian. On this exposition, too, he wrote a comprehensive, enthusiastic report.

Hofmann's work on ammonia and its derivatives, originally prompted by Liebig, was one of the most thorough and exhaustive programs of research ever recorded. New compounds followed in such rapid succession that many were set aside for years before he (or others) returned to them. Following the methods established for his nitrogen bases, Hofmann discovered whole series of analogous compounds of phosphorus, arsenic, and antimony—all of which helped to advance the study of chemical types.

Despite all the personal efforts of the able founder, and the evidence of practical value which was constantly flowing from it, the glamor that had surrounded the Royal College of Chemistry began to wane. Never properly endowed, it gradually failed to attract sufficient public support, and it was merged with the Royal School of Mines in 1853. Prince Albert died in 1861. Hofmann, disappointed at the growing tendency to seize on the results of research and rush new discoveries into commercial production, and temporarily depressed by a succession of personal sorrows, was ready to accept a strong hint from Liebig that he would do well to return to Germany. In 1864 he accepted a call to Bonn, but he remained only long enough to plan a fine new laboratory because in 1865 he was invited to Berlin to succeed Mitscherlich.

In Germany Hofmann recovered his enthusiasm and soon established himself as an inspiring teacher, an ingenious researcher, and a prolific writer. He studied more dyes, organic compounds of sulfur, nitriles (which furthered the knowledge of isomerism) and—following his theory of types—discovered formaldehyde. Continuing, too, his interest in professional organizations and the promulgation of the results of science, he founded the German Chemical Society in 1868, and edited its famed *Berichte* for many years.

It is difficult to estimate the value of the contributions of a chemist like A. W. von Hofmann (he was knighted in 1888) to all the various branches of industry on which his work impinged. Just as the phenylenediamines, which he and an English student isolated in 1863, were not put to practical use for twenty years, much can undoubtedly still be done with many of his other compounds. The door must be left wide open.

As mentioned before, Hofmann had much in common with Wurtz. They met in Liebig's laboratory in 1843 and became lifelong friends. Their work at Giessen included parallel researches on ammonia, but once he returned to France, Wurtz' interests developed in many other branches of chemistry.

Like Faraday and Hofmann, Charles-Adolph Wurtz (1817–84) brought a good background of other studies to his career in chemistry. This was a full course in medicine, chosen as a compromise between the chemistry which was his first choice, and the ministry, which was his father's. Straight through all his schooling, however, in Strassburg and later at Paris, he managed to do all the chemical chores within his reach. After his year with Liebig Wurtz became assistant to Dumas, at the latter's École Centrale, and as the opportunities presented themselves he taught various branches of chemistry in the schools of both medicine and science at the University of Paris.

Wurtz' first original work was on the three acids of phosphorus, and then on phosphorus oxychloride. Other subjects of his research and discoveries that have been of great value were the alkylamines, glycols, aldol condensation, ethylene oxide, lactic acid, and homologues of benzene. His keen interest in metaphysics and in the constitution of matter led him to make a serious study of the atomic theory. His deductions made a valuable contribution to the rather chaotic mass of data that had been accumulating on the subject, especially in its applications to organic chemistry.

Like Hofmann, Wurtz was a careful and thorough organizer of scientific facts. He was a fine speaker and an even better writer. Thrown into one scientific controversy after another—with Berthelot and others—his practice was to marshal the results of his experiments to prove his side. In presenting the facts to his antagonist, or to his students, he never resorted to ridicule or sarcastic criticism of the work of others, but simply offered his own work as the discovery and proof of ideas that were newer and different.

The greatest battle Wurtz ever had to fight was for better appreciation on the part of the French government of the value of scientific research, and the dire need for better laboratories. Private instruction in the laboratories of individual chemists having been the rule for so long, the government was not in the habit of giving any support to classes in chemistry; therefore the only income available was from the fees paid by the

students. In 1868, when his secure position promised some respect for his opinions, Wurtz made a study of various chemical laboratories—especially the university laboratories—in Germany. His excellent report to the Ministry of Education caused a flurry of interest but little practical benefit resulted. A second survey, in both Germany and Austria, in 1878, was equally fruitless, but Wurtz continued his cheerful way, inspiring his eager students to remarkable accomplishments with meager facilities.

There are many distinguished names on the roster of his students: Caventou, Crafts, Fittig, Friedel, Lauth, Lebel, Girard, Tollens, van't Hoff, are only a few of the 111 listed on the monument which they erected in his honor when he was elected a Senator (*not* a political appointment) in 1881. Much as he regretted having to sacrifice some of his teaching for the necessary administrative work, he accepted the responsibility for the good he hoped he might do. Not forgetting his science in his public duties, Wurtz sponsored many improvements in educational curricula; and devised tests which would permit the importation of American meats. He also had women students admitted to the school of medicine at the Sorbonne, and established many free courses in extension.

In 1858, feeling that the long-established Academy of Science did not satisfy the professional needs of the increasing number of chemists, Wurtz cooperated with Dumas, Balard, Pasteur, and others in organizing the Société Chimique de Paris[1] and established its *Bulletin*. After the war of 1870, and the crushing blow caused by the loss of his beloved native Alsace to Germany, he was also a founder of the French Association for the Advancement of Science. The purpose of this group was to decentralize the study and application of science through organizing local meetings for the exchange of information. Discussion of anything relating to the agriculture, industry, or other scientific and technical interests in the provincial centers was encouraged, so that all such matters could be brought to the attention of scientists and of the public. At the first of these meetings, held at Lyon in 1872, Wurtz gave a particularly inspiring introductory address.

Wurtz was highly honored for his work, earlier and more often abroad than at home. As an additional thread of connection among these three men, it is a coincidence that in 1862, when Hofmann was president of the Chemical Society he invited Wurtz over to London to give the Faraday Lecture.

From this observation point in time, it seems odd that anyone of Wurtz' kindly spirit and intellectual honesty should have wittingly and willingly exposed himself to the controversy that inevitably followed his statement that "chemistry is a French science." When Fittig expressed his accumulated rancor in a public meeting (1869), Wurtz said in defense that the notorious sentence and the following one ("It was constituted by Lavoisier, of immortal memory") should never have been separated from their context. Although he expressed his regret for the language in which he had couched his thought, and his high admiration for German chemistry and chemists, in all his voluble explanation he did not actually retract or modify his original statement.

Much as one might wish to keep this little study impersonal, the contribution of these men to chemical industry cannot be evaluated entirely apart from some consideration of their respective personalities. Each was unique in his own circle (Hofmann had two!); each was cast in a pattern that has not been repeated. For if, in the professions, "each generation starts on the shoulders of the preceding," modern conditions could not again produce such examples of native ability, education, and environment. Beside their major contributions, each of these three has handed down pieces of apparatus and many of the devices—both mental and physical—that are now taken for granted in both educational and industrial laboratories. To appreciate all that they were and did we need only to think ourselves back one hundred years—to the America of 1850—to decide whether we could have done as well.

[1] The name was changed in 1906 to Société Chimique de France.

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BUNSEN, BERTHELOT, AND PERKIN

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BUNSEN

If ever a man chose the career for which he was best fitted by nature and temperament, it was Robert Wilhelm Bunsen. The fourth and youngest son of a university professor, the idol of his mother, he was destined to become in due time a teacher and investigator. His work and his character have been aptly summarized by his pupil Roscoe: "As an investigator he was great, as a teacher he was greater, as a man he was greatest."

His life story is very simple. Entering the renowned George Augustus University of his home town Göttingen (founded in 1735 by George II of England, at that time also Elector of Hanover), Bunsen obtained his Ph.D. after seven semesters of study, at the age of twenty. A travel stipend from the Hanoverian government enabled him to spend his "Wanderjahr" in visits to Berlin, Paris, and Vienna, whereupon he returned to Göttingen to become a member of the teaching staff of the university.

In 1836, when he was 25, he succeeded Wöhler as professor of chemistry at a technical school in Cassel. After three years he went to the University of Marburg as assistant professor, and became a full professor there in 1841. From Marburg he went to Breslau in 1851 and from there in October, 1852, to Heidelberg where he taught for 37 years.

At the age of 78 he retired but continued to live as emeritus professor in the town on the Neckar, to whose fame he had so greatly contributed, until his death on August 14, 1899. He never married, saying that he never had found time to do so. His children were the students who came to him from all parts of the globe. Among his German pupils were von Baeyer, Carius, Curtius, Goldschmidt, Kolbe, Landolt, Lothar Meyer, Victor Meyer, von Pebal, Quincke, and Winkler. His best-known English students are Frankland, Playfair, Roscoe, Thorpe, and Tyndall. Americans who studied under Bunsen include: G. C. Caldwell, R. H. Chittenden, J. M. Craft, W. F. Hillebrand, C. L. Jackson, Morris Loeb, L. W. McCay, W. G. Mixter, T. H. Norton, and C. L. Reese, to mention only a few of the better known chemists of the U. S. A.

Bunsen's illustrated lectures were a model of elegance and perfection and were often interspersed with humorous remarks made under the mask of the greatest seriousness. As a pure and simple scientist to whom work was a pleasure and making money distasteful, he gave all his discoveries free to the world. Although polite and friendly to students and assistants, he ruled with an iron hand in a velvet glove, as the undisputed head of the laboratory, suffering no equals next to him, only subordinates under him. Always eager to help students, he lost all interest as soon as any of them pursued plans and ideas of their own.

Being of a practical turn of mind, he took no part in the theoretical discussions which culminated in the congress of Karlsruhe. In spite of the fact that in his early days he made use of what we would now call correct atomic weights, he later employed combining weights (0 = 8) in order to keep away from "hypotheses which are changeable and are often changed." This attitude may have been the result of his experience with organic research in his youth (1837–41) while still in Cassel and later in Marburg. He made an exhaustive study of the fearfully smelling liquid which results from the distillation of a mixture of equal weights of potassium acetate and arsenious oxide, first obtained in 1760 by the French pharmacist Cadet. Bunsen isolated from this liquid cacodyl oxide ($C_4H_{12}As_2O$), the oxide of the so-called radical $C_4H_{12}As_2$ to which Berzelius had given the name cacodyl. He made a number of volatile cacodyl compounds whose densities he determined, thereby obtaining their correct formulas. In reporting this work Bunsen said: "By a glance at this group of substances we recognize in it an unchangeable member, the composition of which is represented by the formula $C_4H_{12}As_2$." This was a great triumph for the so-called radical theory the foundations of which had been laid by Gay-Lussac's work on cyanogen and Liebig and Wöhler's benzoyl studies. Bunsen was, for a while at least, convinced of the "correctness" of this theory. Later on, he found, as stated above, that hypotheses are changeable. While doing the work on cacodyl compounds Bunsen had to breathe through long glass tubes and at one stage of his investigation an explosion occurred which caused a permanent injury to his right eye. Why he ever tackled such evil-smelling, explosive, poisonous, self-igniting substances is not known. Maybe he wanted to test his skill in overcoming obstacles which would have deterred any but the most undaunted experimenters. This was his second encounter with the poisonous arsenic, his first being the successful application of freshly precipitated ferric hydroxide as an antidote in arsenic poisoning.

The discoveries and inventions with which the name of Bunsen is connected are considerable. They were made in a period extending well over 30 years and appeared in various journals. After his death they were collected by Ostwald and published in three volumes in 1904. Bunsen was not a textbook writer like Wöhler and Liebig. He wrote only two small books, one on gasometric methods and the other on flame reactions.

Of the equipment he invented, one of the earliest was the carbon-zinc cell, dating from the year 1841, which

was, for several decades, the only available source of strong electric current. This cell permitted the easy electrolytic preparation of calcium, aluminum, and magnesium. Magnesium burning in the arc generated with the Bunsen cell gave strong light of exceptional intensity. To measure this intensity Bunsen, in 1842, invented his grease-spot photometer which was in use for well over fifty years. For reliable experiments with flames a clean steady flame was required. Bunsen found that the alcohol-wick flame was too variable and the English gas burners supplied with the newly introduced illuminating gas did not satisfy him. His burner, invented in 1855, gave a colorless flame and was ideal for his work. Bunsen's familiar water suction pump dates from 1868, his ice-calorimeter with which he could accurately measure specific heats of elements present in small quantities dates from 1870, and his vapor calorimeter from 1887.

Bunsen's early cacodyl researches were followed by a study of blast furnace gases, partly in cooperation with Playfair, who induced Bunsen to come to England in 1845 to give his advice *in situ*. The next year Bunsen took part in a scientific expedition to Iceland and succeeded in discovering the nature of geysers. Still later he studied the melting point of substances under pressure and found that pressure usually raises the melting point. His deductions were in complete agreement with the familiar Clapeyron equation. In Breslau Bunsen found a new method for iodine titration which was based on the reduction of iodine with sulfurous acid. Early in his Heidelberg period Bunsen undertook, in collaboration with Roscoe, his photochemical researches. The two men were able to confirm and extend the earlier work of Draper (1841) and prove definitely that the amount of photochemical change is directly proportional to the amount of light energy absorbed. The measurement of the light intensity was carried out by means of actinometers. Bunsen and Roscoe also investigated Draper's "photochemical induction" which dealt with the initial slow action of light on hydrogen-chlorine gas mixtures. This strange behavior has finally been traced back (in 1905) to the presence of traces of impurities in the gas mixtures.

These photochemical researches have been reprinted by Ostwald, and Bunsen's latest biographer Georg Lockemann agrees with Ostwald that they are Bunsen's masterpiece in spite of the fact that they are not so well known as his subsequent work on spectral analysis done in conjunction with his friend and colleague in Heidelberg, Gustav Kirchhoff. The latter, thirteen years younger than Bunsen, had been called to Heidelberg from Breslau where he first got acquainted with Bunsen. This appointment, at Bunsen's recommendation, led to such fruitful cooperation that it became the rage to speak of Kirchhoff as Bunsen's greatest discovery.

The spectral analysis as devised by Bunsen and Kirchhoff had its origin in a conversation in which Bunsen explained to his friend that in order to distinguish between flames of different metals he had to view the flames through colored glasses or solutions. Kirchhoff thereupon pointed out that this end could be more simply and accurately attained by passing the light of the flame through a glass prism, thus obtaining the spectrum. The new method was so sensitive that the two men right away found a new metal in the mineral water of Dürkheim which Bunsen, on account of the splendid blue line in its spectrum, called cesium (1860). The following year, the presence of still another alkali metal, obtained from the mineral lepidolite, was announced. This was rubidium. In rapid succession two other elements were spectroscopically detected: thallium by Crookes (1861) and indium by Reich and Richter (1863). Bunsen and Kirchhoff grasped the significance of their new method at once, for, as Bunsen wrote to Roscoe: "A means has been found to determine the composition of the sun and fixed stars with the same accuracy as we determine sulphuric acid, chlorine, etc., with our chemical reagents."

The discovery of spectral analysis was the high-water mark in Bunsen's career. It increased his fame enormously and led to his being called to Berlin as successor to Eilhard Mitscherlich who died in 1863. Bunsen, who was no admirer of Bismarck, declined and was rewarded by a substantial increase in laboratory funds and the appointment of his friend Kopp to a professorship in Heidelberg.

In his last 25 years as a professor (1864–89) Bunsen confined his activities more to teaching and devoted less time to research. His final publication, which discusses his vapor calorimeter, appeared in 1887, when he was 76 years old.

BERTHELOT

It is generally conceded that Berzelius covered the whole field of chemistry at the beginning of the nineteenth century. With the rapid progress made between 1800 and 1900 it became more and more difficult to contribute to this branch of knowledge in *all* its ramifications. This was done, however, to a remarkable extent by that most prolific and versatile chemist of the second half of the nineteenth century, Marcelin Berthelot. Between 1850 when he wrote his first paper on a method of liquefying gases, and the time of his death (March 3, 1907), he published well over 1000 papers and some eighteen or twenty books. With this phenomenal contribution to science he is unquestionably the lineal descendent of the encyclopedists of the preceding century. No one but a man of genius, whose sole ambition it was to further human progress by scientific discoveries, could have accomplished that tremendous amount of work which remains forever a monument to his brilliant achievements. This he carried out first of all for the benefit of his beloved homeland. On the monument erected in his honor in Paris, which disappeared in 1942, only three words were engraved: *amitié, amour, patrie*, to characterize his devotion to his lifelong friend Renan, to his wife, and to his country. France has, more than once, called upon its scientists to

manage the affairs of the country and Berthelot's name can be placed beside those of Berthollet, Carnot, Fourcroy, and Dumas.

Of the many biographies that have come to the writer's notice, only one mentions specifically the profound effect which the war of 1870 exerted on Berthelot. It is often stated that science knows no boundaries but as Pasteur once remarked: "Every scientist is part and parcel of the country where he was born, lived, and worked." There can be no doubt that a successful war acts as a stimulant in some directions and the rapid increase in population in Germany after 1870 coincides with an accelerated activity in scientific endeavors. On March 10, 1871, Claude Bernard, the famous French physiologist, wrote to his friend Robin: "Ce qui m'attriste, en un mot, c'est de voir que nous sommes vaincus scientifiquement." Pasteur, ten days later, bemoaned the downfall of his country in the following words: "Le salut de la France a été la conséquence exclusive de sa supériorité scientifique."

Berthelot, as an ardent patriot, decided to do something to restore, if possible, that superiority. Although he had already found, as early as 1862, that the acetylides of silver and copper readily explode, it was not until 1870 that he began to study the explosive force of powders. This work was continued for several years with his pupil Vielle. He found that when an explosive mixture is fired the flame proceeds at a gradually increasing rate until a maximum is attained, the maximum depending on the chemical composition of the mixture. In 1878 he examined explosive mixtures of dust with air. In 1884 measurements of the specific heats of gases at high temperatures were made and in the course of this work he invented his well-known calorimetric bomb. This bomb was later (in 1892) adapted to the determination of heats of combustion of organic compounds. The studies on explosives were followed by investigations dealing with problems of vegetable chemistry. These were performed in a fine new laboratory erected on the heights of Meudon in 1884. Here, in cooperation with his pupil André, he carried out numerous researches, the results of which were summarized in his "La chimie végétale et agricole," published in 1899. The results obtained led to a confirmation of conclusions reached elsewhere.

Berthelot's historical studies which, likewise, cover the last thirty years of his life were undertaken with the aid of prominent philologists. They are a fine example of what we are now accustomed to call "teamwork," with Berthelot as organizer at the top. They were subsidized by the Académie Française.

Berthelot's historical contributions comprise: "Les origines de l'alchimie" (1885), "Collection des anciens alchimistes Grecs" (1885–87), "Introduction à l'étude de la chimie des anciens et du Moyen Age" (1889), "La révolution chimique," "Lavoisier" (1890), "La chimie au Moyen Age" (1895), and "Archéology et histoire des sciences" (1906).

Berthelot's brilliant work in organic synthesis, known to all students of chemistry, was performed in his early, most productive period, from 1850 to 1870. In his inaugural thesis (1854), he showed that glycerol stands in the same relation to ethyl alcohol as phosphoric acid to nitric acid, thereby introducing the concept of polyatomic alcohols. Whereas Chevreul had analyzed the fats some thirty years earlier, Berthelot succeeded in synthesizing them and in so doing produced three series of glycerol esters which he, mistakenly, compared to ortho-, pyro-, and metaphosphates, an error which was subsequently corrected by his rival Wurtz (1817–84). In this work on fats Berthelot had already noticed that time was needed for the reaction to proceed. This led him, some years later, to study rates of reaction in the esterification of acetic acid, in collaboration with his pupil Péan de Saint-Gilles (1834–63). The synthesis of organic compounds which occupied Berthelot fully until 1870 and was continued even to a later date (his "La synthèse chimique" appeared in 1876) was undertaken to demolish the wall that seemed to separate organic from inorganic chemistry. It is true, as his pupil Sabatier once said, that there were cracks in that wall. This was demonstrated by Wöhler, in 1828, with his urea synthesis and later by Kolbe, in 1845, when the latter synthesized acetic acid. But it was Berthelot who, starting from the elements, synthesized the various hydrocarbons from which, by further treatment, alcohols, acids, and other derivatives could be obtained. It was this phenomenal achievement that created for Berthelot the chair of organic chemistry at the Collège de France which he occupied until his death.

The study of organic compounds led Berthelot to the consideration of chemical equilibria and reaction kinetics, the results of which were published in his "Essay de Méchanique Chimique" (1879). His work on esters which foreshadowed the enunciation of the law of mass action two years later (in 1864) and the distribution law of Berthelot and Jungfleisch may be mentioned in this connection.

The work on thermochemistry got its start around 1864 when his organic syntheses were, by and large, finished. The results were published in book form in 1883, 1893, 1897, and 1899. Much of this work was a confirmation of laws previously enunciated and established by others. Berthelot speaks of the three principles of thermochemistry, the last of which, the principle of maximum work, he claims to be the "most original" and exclusively his own. Unfortunately, it is this last principle that has met with severe criticism and is now abandoned as being incompatible with the facts.

This brief and incomplete sketch of Berthelot's work gives some idea of the striking personality of the most versatile French chemist of the nineteenth century. In some respects he was like Bunsen: none of his discoveries was ever patented. He also retained persistently the old system of representing formulas, even as late as 1890, when chemists everywhere had been converted to Cannizzaro's system. Though he was drawn into politics for brief periods of time, his life, like Bun-

sen's, was devoted to the pursuit of knowledge. As he said himself: "Adonné, dès mes débuts dans la vie, au culte de la vérité pure, je ne me suis jamais mêlé à la lutte des intérêts pratiques qui divisent les hommes. J'ai vécu dans mon laboratoire solitaire, entouré de quelques élèves, mes amis."

Berthelot was born in Paris on October 27, 1827, the son of a doctor of medicine who was a serious man, somewhat depressed by the poverty and misery of his patients. His mother, a devout Catholic, was a cheerful, vivacious person, whom Berthelot greatly resembled. At the age of nineteen, when finishing his high-school years at the Lycée Henri IV, he obtained the *prix d'honneur de philosophie* at a competition open to the graduating pupils of all the *lycées* of Paris. Around this time also, he first met Ernest Renan, four years his senior, who became his lifelong friend and kept up a correspondence with Berthelot which lasted from 1847 to his death in 1892. While studying for his doctor's degree, Berthelot, in February, 1851, became lecture assistant (*préparateur*) to Balard, the discoverer of bromine, who taught chemistry at the Collège de France. He kept this position for nearly nine years, until December, 1859, when he was made professor of organic chemistry at the École Supérieure de Pharmacy, and gave up the latter position for the chair of professor of organic chemistry at the Collège de France. In 1861, he married Sophia Niaudet, ten years his junior, probably against the wish of his mother since his fiancée was a Protestant. Though Berthelot himself was an atheist, his marriage was singularly happy. The Berthelots had four sons, one of whom became a noted physicist, and two daughters. The story of the courtship of Berthelot, as told by Ramsay, does not agree with the facts and all one can say is: "Se non è vero, è ben trovato." Berthelot and his wife died within a few hours of each other, and both lie buried in the Panthéon.

PERKIN

Considering Perkin to be the father of the coal-tar dye industry, we might well look upon his teacher, Hofmann, as the grandfather and on Hofmann's teacher, Liebig, as the great-grandfather of this highly important industry. In fact, it was Liebig's "Chemistry of Agriculture and Physiology," published in 1840, that caused considerable commotion in the civilized world, and his subsequent visit to England in 1842 increased greatly Britain's interest in chemistry. The immediate result was the founding of the Royal College of Chemistry in London, due to the initiative of the Prince Consort Albert and of Queen Victoria's physician, Sir James Clarke. Prince Albert thereupon induced Hofmann, a pupil of Liebig, to become its first director in 1845. Hofmann, while still a student at Giessen, had isolated from coal tar a compound, discovered by Unverdorben, to which the name aniline (from anil = indigo) had been given. Hofmann and his English pupils began an intensive study of this compound and of other products obtained by fractional distillation of coal tar. One of his students was a precocious boy of fifteen, William Henry Perkin, the youngest son of a builder and contractor who was destined to become an architect. It so happened, however, that he came in contact with a capable science teacher, Thomas Hall, who interested Perkin in chemistry and called his attention to the renowned director of the Royal College of Science. Hall persuaded Perkin's father to let the boy pursue chemistry as a career. As Perkin says in his autobiography: "I saw there was in chemistry something far beyond the other pursuits with which I had previously been occupied. The possibility of making new discoveries impressed me much. . . . I immediately commenced to accumulate bottles of chemicals and make experiments."

Having gone through the routine methods of qualitative and quantitative chemistry, young Perkin, at the age of 17, became private assistant to Hofmann. His first task in this capacity was to nitrate anthracene and to reduce the resulting product. The experiment failed, whereupon Hofmann assigned him the study of the action of cyanogen chloride on naphthylamine. This research was successfully completed and was published in 1856 when its author was 18. It was the first of a long list of publications which continued for over fifty years to 1907, the year of his death. Although Perkin was kept very busy by his famous chief his thirst for knowledge was insatiable, and in a little private laboratory in his own home, first fitted up in 1854, he tried to carry out some of his own ideas. By oxidizing toluidine he expected to arrive at the alkaloid quinine. However, no quinine was formed and only a dirty reddish-brown precipitate resulted. As Perkin stated later: "Unpromisipg though this result was, I was interested in the action and thought it desirable to treat a more simple base in the same manner. Aniline was selected and its sulphate was treated with potassium chromate; in this instance a black precipitate was obtained, and on examination, this precipitate was found to contain the coloring matter since so well known as aniline purple, or mauve, and by a number of other names." This epoch-making experiment, first performed in the Easter vacation of 1856, was repeated again and again and at the suggestion of his friend, A. H. Church, Perkin decided to patent his invention. It was probably his artistic bent, which as a youngster had induced Perkin to work away at painting, that gave him the idea to exploit this unexpected result commercially. With no experience whatsoever, and against the advice of Hofmann, Perkin started his career as the first practicing "chemical engineer" at eighteen. Ten months after his first patent was granted, enough aniline purple, as the dye was then called, was produced to supply one of the London silk dyers. Nevertheless, progress was slow in the infant industry and it was not until 1859 that the value of the new product was recognized.

It was the Société Industrielle de Mulhouse in Alsace-Lorraine which awarded him a silver medal (and later a gold medal). As a consequence, Perkin's first dye was known almost exclusively as mauve or mauveine.

Success of the new dye stimulated further research. Magenta was successfully manufactured in France in 1859, aniline blue or *bleu de Lyon* in 1861. In 1862 Hofmann, who took a leading part in the study of the new dyes, showed that magenta is the salt of a base which he called rosaniline. The structure of many aniline dyes became known rapidly after Kekulé had established the structure of benzene in 1865, but it was not until 1888, more than twenty years after Perkin's discovery, that mauveine was recognized as a phenyl derivative of phenosafranine.

Although engaged as a manufacturing chemist, Perkin assigned the actual running of the dye factory at Greenford Green to his older brother. This left him enough time to carry out organic researches not directly related to dyestuff chemistry. With Duppa, he succeeded in synthesizing glycine and tartaric acid (1860–64) and around 1867 he started work on the action of acetic anhydride on aromatic aldehydes, which led to the celebrated Perkin synthesis. This enabled him to complete, in 1868, the synthesis of coumarin, the odorous constituent of the Tonka bean, thus inaugurating the first artificial production of a vegetable perfume. His synthesis of cinnamic acid made possible the work of von Bayer and Caro on indigo. When Graebe and Liebermann, in 1868, showed that alizarin is a derivative of anthracene and secured, in the same year, a patent on its manufacture, Perkin again experimented on the material with which he had made his scientific debut. Realizing that the method outlined in the German patent was too expensive to compete with the natural product obtained from madder, he simplified the process by eliminating the use of bromine and made his alizarin by starting from dichloroanthracene or from sulfonated anthraquinone. This second method had, meanwhile, also been worked out in Germany and by a curious coincidence the German patent was granted on June 25, 1869, and Perkin's the following day. The competitors avoided a litigation by assigning the German patent to the continent and Perkin's patent to England.

In 1874, after 18 years of experience as a manufacturing chemist, Perkin, at the age of 36, retired to spend the rest of his life as an independent researcher. Perkin has sometimes erroneously been blamed for leaving the field of applied chemistry, thereby slowing down the progress of the budding dye industry in his native land. It must not be forgotten that it was Hofmann who induced his countrymen Martius and Griess to come to England. Caro, another German, had been attracted by Perkin's discovery and came over to work for the firm of Robert and Dale in Manchester, in 1859. These men aided materially in the development of Britain's new dye industry. However, progress began to slacken after a while because the structure of the new products was not known and could not be known for some time. It was only after Kekulé, while still at Ghent (Belgium), had solved the riddle of the benzene structure that further progress could be made. Hofmann, "seized with a profound homesickness for the spiritual heights of a German University," left London in 1865 to fill the chair of chemistry left vacant by the death of Eilhard Mitscherlich in Berlin. Kekulé, another pupil of Liebig, left Ghent in 1867 to become professor of chemistry at Bonn. Martius followed his teacher Hofmann, and Caro also returned to Germany in 1866, becoming a director of the newly established Badische Anilin- und Sodafabrik at Ludwigshafen in 1869.

When Perkin quit in 1874 he built himself a new home at Sudbury and converted his former residence into a laboratory. Here he continued the study of the materials which had occupied him previously as a manufacturer. Gradually he drifted into a new field of study with which the name of his illustrious compatriot, Faraday, is connected. The first communication on "rotatory polarization by chemical substances under magnetic influence" appeared in 1882 and was followed by further installments up to the time of his death, 25 years later. This work, highly praised by his contemporaries and mentioned even in elementary textbooks of physical chemistry, has lost a good deal of its value, as a result of the later more reliable methods of structural investigation of organic compounds.

Perkin was an extremely modest man, a model husband, and father of three sons (all trained chemists) and four daughters. As a private, nonacademic researcher he had few collaborators and no pupils. Although favorably known in his own country, he received only belated recognition from the outside world. Apart from one honorary Ph.D. degree, conferred on him by the University of Würzburg in 1882, he received no academic distinctions outside England except near the very end of his life. Then the commemoration of the discovery of the first coal-tar dye set in motion a series of jubilee celebrations which must have been a considerable strain to a man of retiring habits and extreme frugality. The American Chemical Society, which had included both Bunsen and Berthelot among its honorary members in the year of its founding in 1876, did not put Perkin on its honor roll until 1906. The first American "Perkin" medal was presented to Perkin in the fall of 1906, on his first and only visit to this side of the Atlantic. The ordeal of this strenuous American tour was such that it probably hastened his death which came on July 14, 1907.

METALLURGY IN THE NINETEENTH CENTURY

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Of the 90 odd elements about 70 in their elemental state are metals but here only the more common will be considered. Steel, aluminum, and a few nonferrous metals will be stressed. Steel will receive most attention because of its dominating position in the metal industry. Well over 90 per cent of all the metal produced is steel. This is illustrated in Table 1 which shows the U. S. metal production in 1871 and in World War II. It is this relative position of steel that makes it the backbone of the metal industry and the foundation of our modern industrial civilization. The steel age really started in the 1850's; prior to that time the ferrous product was iron. The iron and steel industry started before the days of science as we know it today. A tremendous amount was learned about the production and properties of steel and the information was, for the most part, developed empirically. It may be said that the practice of making and using iron and steel far outran the underlying science. In fact it has not been until the last 25 years that some of the basic principles have begun to be appreciated.

TABLE 1
U. S. Metal Production

Commodity	*1871, tons*	*World war II record year, tons*
Pig iron	1,900,000	62,800,000
Steel	84,000	89,600,000
Copper	14,000	1,115,000
Lead	19,800	496,000
Zinc	7,000	768,000
Aluminum	None	918,000

In contrast to this is the situation in the aluminum industry. The relatively recent start of this industry brought it into a world where science was already becoming recognized as an important part of technology. Consequently the aluminum industry grew out of science and the rapid and substantial growth of this industry was greatly aided by science. It is not the purpose of this paper to compare the different metals, but the case of steel and aluminum raise some interesting questions of a technical nature. The gigantic steel industry is quite often referred to as backward in science and research. Although this industry produces far more metal at a much lower cost per pound than all the other metal industries, its present powerful position could probably have been achieved at a much lower cost, if the modern approach of scientific research had been available and more extensively used.

Frequently the competition among the metals for specific uses is stressed. Here, however, the mutual assistance of the metals seems more significant. When the automobile industry was developed it might seem, because of the extensive use of steel, that this was preeminently a steel development. The average percentage of steel in an automobile is about 84. Many other metals have found the automotive industry an important outlet for their products. In spite of competitive readjustments of the individual markets, the family of metals has continued to rise together. This is very well illustrated by the steel industry, which in itself, is a great user of nonferrous metals. Table 2 illustrates this point.

TABLE 2
Partial List of Nonferrous Metals Used by Steel Industry

Metal	*Tons required*
Steel production	90,000,000
Manganese	600,000
Silicon	200,000
Chromium	150,000
Nickel	125,000
Molybdenum	30,000
Tungsten	10,000
Vanadium	3,000

THE IRON AND STEEL INDUSTRY

In spite of the limited scientific help available, the iron and steel industry had to solve some difficult and important technical problems in the nineteenth century. The principal fuel used for the industry, at least in some parts of the world, changed from charcoal to anthracite, and then to coke. Each change was attended by a multitude of problems. Refractories came in for their share of study, and mechanical handling of materials required much attention for it formed a large part of the cost of steelmaking. In spite of these problems, production of iron and steel increased at a rapid rate, as shown in Figures 1 and 2. Figures for the twentieth century have been included to serve as a measure of comparison.

Most of the early development took place in Europe, with Great Britain leading the way. Toward the end of the century, however, her leadership in steelmaking was being challenged both in Europe and by the United States.

Studies of the production figures for iron and steel from 1865 to the turn of the century bring out some interesting points. Iron production is shown in Table 3 and steel production in Table 4.

In 1865 Great Britain produced considerably more pig iron and more steel than France, Germany, and the United States together. By 1905, however, the United States was producing almost twice as much pig iron

and more than twice as much steel as the other three combined, and Germany had surpassed Great Britain by a considerable margin in steel production and by a smaller margin in iron production. As a matter of fact, Great Britain was probably still leading in iron production by a small margin at the turn of the century.

Rickard, in his book, "Man and Metals," explains the metallurgical and industrial leadership of Great Britain in the following terms:

> Thanks to the inventive genius of her own sons, England was enabled to make the most of her resources in iron and coke; in 1865 she produced more iron than all the rest of the world; indeed, not long before that date her exports of the metal had equalled the gross production of all other countries; her pre-eminence was unchallenged not only as the chief iron-producer but as the industrial leader of the world, for one is the consequence of the other. England's commercial ascendance in the nineteenth century was due to the possession of ample deposits of both iron and coal, and their proximity to each other, together with an energetic population, directed by capable captains of industry. The same conditions and capacities were developed subsequently in the United States.

The position of leadership that Great Britain attained and held in the nineteenth century was based, in no small measure, on the inventiveness of her citizens. They had developed a strong foundation in iron-making in the eighteenth century. Nielson applied

TABLE 3
Production of Pig Iron by Countries

Year	*Great Britain*	*United States*	*Germany*	*France*
1865	4,897,971	843,410	988,191	1,203,710
1875	6,469,219	2,056,750	2,029,389	1,448,272
1885	7,368,842	4,110,600	3,687,434	1,639,648
1895	8,022,006	9,597,449	5,788,798	3,005,889
1905	9,746,221	23,340,258	10,987,623	3,077,000
1912	9,037,150	30,202,567	17,852,571	4,871,992
1925	6,207,800	36,700,600	10,046,800	8,323,100

TABLE 4
Production of Steel by Countries

Year	*Great Britain*	*United States*	*Germany*	*France*
1865	225,000	13,848	97,752	40,574
1875	723,605	396,165	370,665	256,393
1885	2,020,450	1,739,883	1,202,990	553,839
1895	3,444,201	6,212,671	3,941,300	899,676
1905	5,983,691	20,354,291	10,066,553	2,210,284
1912	6,689,118	31,751,324	17,868,909	4,078,352
1925	6,136,700	45,393,500	12,176,200	7,289,700

the hot blast to the iron furnaces. Bessemer contributed much to the steelmaking process which bears his name. He was a particularly prolific inventor. It is said that in his lifetime he spent over 10,000 pounds on patent office fees and many of his inventions applied to the steel industry. The open hearth process of Siemens (and Martin in France) was developed after some preliminary work by Heath about the same time as the Bessemer process but did not nearly equal it in importance as a steel producer until the twentieth century. At present it leads by a considerable margin. Thomas and Gilchrist developed the basic Bessemer

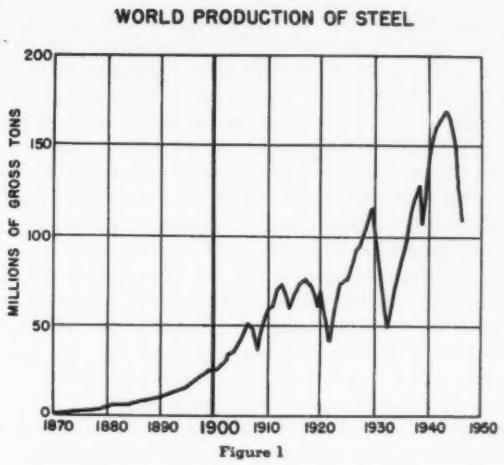

Figure 1

about two decades later—a process which has been widely used in Europe. In addition to these major contributions, the scientists of Great Britain made many other developments of a less spectacular nature.

The rapid growth of steel production in Germany was in part due to the iron that came from Lorraine, which was taken from France as a result of the war of 1870. In 1913 some 80 per cent of the iron consumed by Germany came from that district. This area was later turned back to France. Rather peculiarly the boundaries drawn after the war of 1870 left the Briey basin to France. This was apparently done either in ignorance of the fact that the iron deposits extended south of the new border or that the type of ore in them was valuable. They comprised the so-called minette deposits which were high in phosphorus. Less than ten years later the Thomas-Gilchrist basic converter was developed and it became feasible to smelt the minette ores. The district thereby became more valuable than that annexed by Bismarck. It might be mentioned that at the beginning of World War I the Germans immediately invaded the Briey basin and had the use of that ore throughout the war.

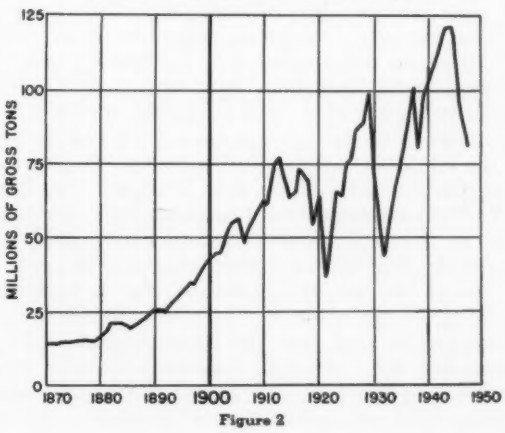

Figure 2

Somewhat earlier it was pointed out that Great Britain had led in steelmaking the greater part of the nineteenth century. Rickard has explained the leadership as a combination of adequate raw materials, industrial enterprise, an energetic population, and inventive genius. In groping for the answer as to why Great Britain led in the nineteenth century but lost the lead with the approach of the twentieth century, it does not appear that Germany, France, or the United States were particularly lacking in the above characteristics, although, in the nineteenth century, the British, on the basis of the record, might be said to lead in inventive genius. But the United States, Germany, and France were able to adopt the British inventions and then push on to developments of their own. It is possible, now that we see all four countries strongly industrialized, that a major factor which determines the metal production is the population which forms the market for the product. And Great Britain with the smallest population, and lacking in the size of its territory and the general abundance of its resources, could not keep pace with those countries more favored in these respects. At the present time the size of the population and the standard of living that the general resources of the country will allow are quite definitely factors in the current rates of steel production.

One factor, according to Rickard, that made the iron industry of Great Britain strong in the nineteenth century was the ample deposits of coal and ore in close proximity to each other. No doubt that was desirable and perhaps essential for the start of the industry but current conditions would seem to indicate that this is not necessary to sustain the industry. At present in the United States, Pennsylvania coke is being used extensively to smelt Minnesota ores. Furthermore, the steel industry of the United States is currently developing sources of ore in Canada and South America.

Thus far the impression has probably been given that Great Britain alone made all of the important developments in steelmaking. This is not quite true. The development of the open hearth furnace was partly a French development with Martin a major contributor. The Germans contributed much to the improvement of the blast furnace. The principle behind the Bessemer process was first tried by an American named Kelly, but Bessemer and Mushet, two Englishmen, generally are given credit for making the process succeed. While the contribution from America to the steelmaking of the nineteenth century was limited, its contributions to the fabrication of the steel were considerably more important. Cold rolling was developed by Lauth while Fritz developed the three-high mill. Nevertheless, in spite of these contributions to production metallurgy, the world depended quite heavily on Great Britain in the nineteenth century for its leadership. As C. D. King remarks, "In retrospect, it is quite interesting to note that the basic principles of steel production have changed but little in this period (1870's to present). . . . The regenerative Siemens furnace has been modified in size, durability, and performance, but not in principle; the Bessemer employs essentially the very same principle as in 1870; and the electric furnace, while of more recent origin, has changed in mechanical phases rather than in principles of steelmaking. But apart from basic principles, there is nothing in common between present day facilities or methods and those employed years ago." Comparison of pictures of old facilities and modern ones bear this out.

PHYSICAL METALLURGY

Until now we have considered just the production metallurgy and have noted the leadership of Great Britain and the active cooperation and interchange of information between the nations. Physical metallurgy presents a somewhat different picture. Here the contributions seem to be spread more uniformly among the nations and were made by scientists rather than plant people. This work was quite extensive during the eighteenth century; here, however, we will confine our attention to the nineteenth century. No attempt will be made to treat the subject comprehensively; rather selected examples will be used to illustrate the existing situation.

Karl Karsten in Germany isolated the carbon of soft steel in 1827, and other investigators of varying nationalities clarified the subject. Tchernoff, a Russian, is considered the father of the critical points of steel, for he proved in 1869 that steel cannot be hardened unless heated above a certain specific temperature. Gore, Barrett, and Tait also contributed to the subject of hardening steel.

There were many valuable contributions on the subject of mechanical properties of metal. In 1807 Thomas Young, an English physicist, described the modulus of elasticity, and Thomas Tredgold, an English civil engineer, using Young's information, scientifically considered in 1822 the question of strength of metallic materials. Hodgkinson in England in 1830 studied the behavior of beams and girders under stress, and Squire Whipple of the United States in 1847 studied

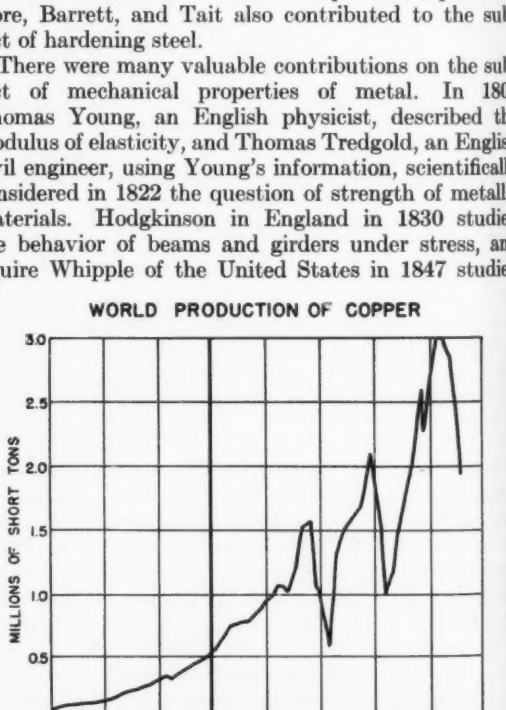

Figure 3

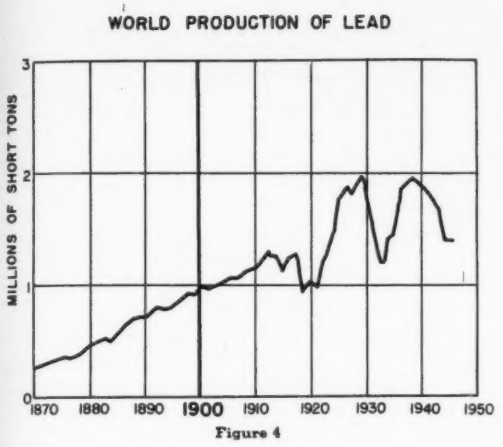

Figure 4

the stresses in framed structures. Whipple presented the first scientific and correct analysis of bridge building, which replaced the old empirical methods. By 1871 the mechanical testing of metals was well established.

The French were leaders in the study of the elasticity of metals. The scientists, whose work in this field was noteworthy, were Cauchy, Matteucci, Wertheim, Poisson, Navier, Lame, Clapeyron, and Sain-Venant, and by 1871 the theory of elasticity had practically been completely formulated.

The influence of repeated stresses was a field in which the Germans were prominent. Albert in Germany recognized the effect as early as 1829. Hodgkinson, Fairburn, James, and Galton did considerable work in England, but Wöhler was probably the outstanding investigator in the field. He found limiting endurance stress values for metals and noted the deleterious effect of notches.

Metallography was developed in the early part of the nineteenth century but its extensive practical use did not take place until the twentieth century. Widmanstätten in Vienna in 1808 did some of the earliest work. Sorby in England did considerable good work, but it did not arouse much attention in England. Martens in Germany did a great deal of metallographic microscopic work, particularly on cast iron. His work was important and influential in Germany and France. Anosoff in Russia did some interesting metallographic work in 1841 but it did not come to the attention of scientists outside of Russia. Tchernoff, however, in his famous paper on the critical temperature described the dendritic structure of ingots. America does not appear to have contributed much to microscopy until the last decade of the nineteenth century when Howe and Sauveur published some interesting papers and a symposium was held in 1894 on the "physics of metals."

The physical metallurgy of the nineteenth century was extensive and important. The work was well distributed over the various countries, and while the British may have held a slight leadership, it was not nearly as pronounced as it was in production steel metallurgy. The physical metallurgy, however, had one thing in common with production metallurgy; they both dealt largely with iron and steel. The coordination between the physical metallurgy and production was not particularly good. The United States moved into leadership in metal production with a minimum of physical and production metallurgy. It would almost seem as though you can have your industry prior to the development of production metallurgy by borrowing from others, while physical metallurgy in the case of steel seems to be almost independent of industry.

COPPER, LEAD, AND ZINC

Copper, lead, and zinc will be but briefly discussed, not because they were unimportant but because steel and aluminum represent the extremes among the metals produced in large quantity. Copper, for example, has a long history of use, longer, in fact, than that of steel. Like steel, however, its extensive use did not really take place until the end of the nineteenth century, and that was the start of a tremendous expansion in the twentieth century. World production figures are given in Figure 3. The production curve is much the same as that for steel and the United States has been the leading producer since 1883, except for two years in the 1930's when Chile led.

Lead, on the other hand, shows a somewhat different pattern, as illustrated in Figure 4. The rise is less spectacular and the world production failed to

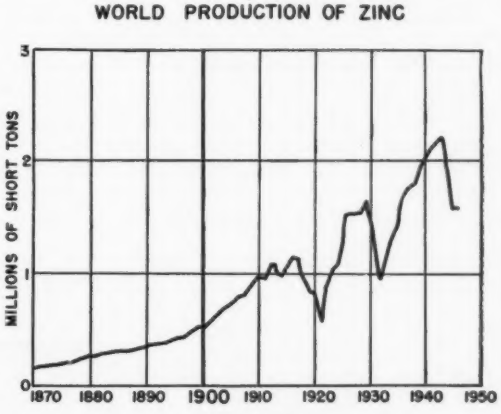

Figure 5

reach a new high in World War II. The United States again held the lead in production almost every year since 1880 when she moved ahead of Spain.

Zinc production, as shown in Figure 5, shows the same general upward trend as copper but the rise is not so spectacular. Zinc production was well established in Europe in 1870 and just starting in the United States. However, by 1910 we had passed Germany.

The problems of the copper, lead, and zinc industry

were somewhat like those of steel in that a substantial industry had been built by empirical methods before science became strong. Nevertheless these industries, like the aluminum industry, quickly embraced modern scientific methods, and the various nonferrous industries have strong research organizations.

THE ALUMINUM INDUSTRY

Not because it had arrived at a position of importance in the nineteenth century (see Figure 6) but rather because of its different origin and antecedents, the aluminum industry will be described here. Aluminum, unlike iron, cannot be traced back into antiquity. It

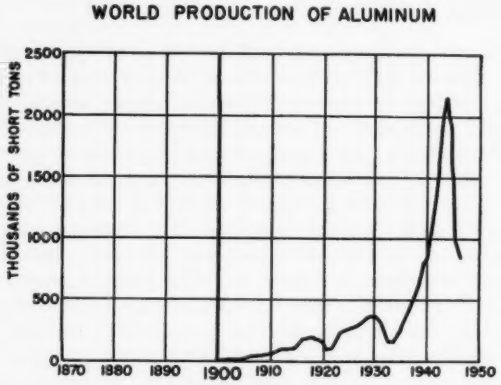

Figure 6

was first produced in 1825 by Oersted, a Dane, by heating potassium amalgam with aluminum chloride, but there was a controversy as to whether or not he produced metallic aluminum. It is now generally conceded that he did. Friedrich Wöhler two years later in Germany succeeded in reducing it with potassium. H. Sainte-Claire Deville improved Wöhler's method in 1854 by substituting sodium for the potassium. Aluminum was made in limited quantities by the Deville method but was quite expensive. English investigators were also working on the reduction of cryolite. Castner, an American, in 1886 developed a low cost method for making sodium thereby reducing the price of aluminum. Bunsen, Sainte-Claire Deville, and others tried to electrolyze salts of aluminum but did not succeed in developing a commercial process. Hall, an American, while a student in college, finally solved the problem in 1886 by electrolyzing a solution of alumina in cryolite. Paul L. T. Heroult was granted a similar patent in France at almost the same time. This process went into operation in 1888 in the United States and forms the basis for the production of aluminum throughout the world.

A striking thing about the development of the aluminum industry was the fact that it was so soundly based technically. The names, in large part, of those engaged in the development of the process are those of outstanding scientists. There has been from the very beginning of the industry a close relationship between science and production. It is quite a contrast from the steel industry which was largely developed before science became of age, while the aluminum industry was developed after. As a consequence, in order to develop the necessary background of technical data rapidly, and make possible the phenomenal growth of this new industry, it was necessary to bring to bear the full force of scientific research on the problem.

ACKNOWLEDGMENT

The author gratefully acknowledges his sources of information which are given below. Tables 4 and 5 came from Rickard; the information in the others and the figures were taken from the A.I.M.E. book.

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MAXWELL'S DAEMON

Maxwell's daemon has remained since 1871 as a paradoxical being who, with the aid of fine enough faculties and a frictionless door could transfer heat from a system at a lower temperature to one at a higher "in contradiction to the second law of thermodynamics."

Eighty years later, Maxwell's paradox has been paid the compliment of resolution by L. Brillouin, of the International Business Machines Corporation, New York, as an introduction to some serious discussion of the theory of communications.

"Let us suppose," he quotes, "that a vessel is divided into two portions A and B by a division in which there is a small hole, and that *a being who can see the individual molecules* opens and closes this hole, so as to allow only the swifter molecules to pass from A to B, and only the slower ones to pass from B to A." The italics are Brillouin's, and indicate the basis of his criticism.

"The daemon," he points out, "is in an enclosure at a constant temperature, where the radiation must be that of a 'black body,' and it is impossible to see anything in the interior of a black body.

"It would not help to raise the temperature. At red temperatures, the radiation has its maximum in the red, and obtains exactly the same intensity, whether there are no molecules or millions of them in the enclosure. Not only is the intensity the same, but also its fluctuations.

"The daemon," he concludes, "cannot see the molecules, hence he cannot operate the trapdoor, and is unable to violate the second principle."

Further, if he is provided with an electric torch or the equivalent with which to see the molecules, then also he fails; the minimum net change being in the direction of a degradation of energy. —*Science To-day.*

THE USE OF FLUORESCENCE IN QUALITATIVE ANALYSIS

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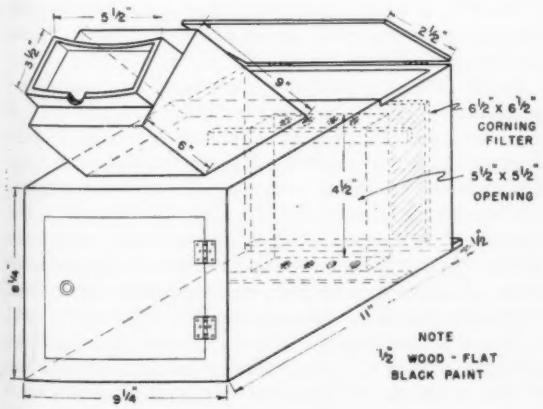
THE hesitancy of teachers to use fluorescence in elementary qualitative analysis is probably due to three reasons: first, the impression that the techniques are difficult; second, the belief that the apparatus is expensive; and third, the fact that definite instructions which may be given to the student for applying these methods are not available. It is the purpose of this paper to show that the techniques are simple, that the apparatus required is inexpensive, and to outline procedures which may be used in any scheme of qualitative analysis.

Fluorometric reagents afford much more specific and more sensitive confirmatory tests than those usually employed for several of the elements. The tests are generally very definite and a student does not have to wonder whether the result is positive or negative. The procedures described here have proved successful in the author's classes for many years. For convenience in duplicating the experiments, a source of supplies is given at the end of this article.

APPARATUS

The essential equipment for fluorescence observations in the qualitative laboratory is a view box and a source of ultraviolet light. Figure 1 shows the dimensions of a view box designed for use with 6- × 1/2-in. test tubes which is similar to the visual comparator described by Fletcher and others (*1*). This is painted on the inside with a flat black paint; a glossy paint causes too much reflection. The hinged door at the back of the box is not necessary but is convenient for inserting solids in order to observe their fluorescence. A Corning No. 5874, 6 1/2-in., blue-glass filter is used to transmit the ultraviolet light and exclude the visible. A convenient source of ultraviolet light for this view box is two 6-in., 4-watt, clear glass 360 BL fluorescent light tubes arranged as illustrated in Figure 2. These tubes require a small ballast transformer and starter. An entire outfit, including a tube, bracket, ballast, and wire, can be purchased under the name of a Blacklite System, or completely assembled holders for one or two tubes can be obtained. Two of these tubes give a sufficient amount of ultraviolet light for most laboratory purposes. The tubes furnished with the Blacklite Systems are made of blue glass which is useful for demonstration purposes but is not necessary when a filter is to be used. In practice the tubes should be backed with an aluminum reflector. Quite a satisfactory source of ultraviolet light is obtained by placing an 18-in., 15-watt 360 BL tube in an ordinary balance lamp or desk fixture. The designation 360 BL indicates that the tube is coated with a phosphor which has an appreciable emission in the vicinity of 3500 to 3600 Å.



VISUAL COMPARATOR

Figure 1

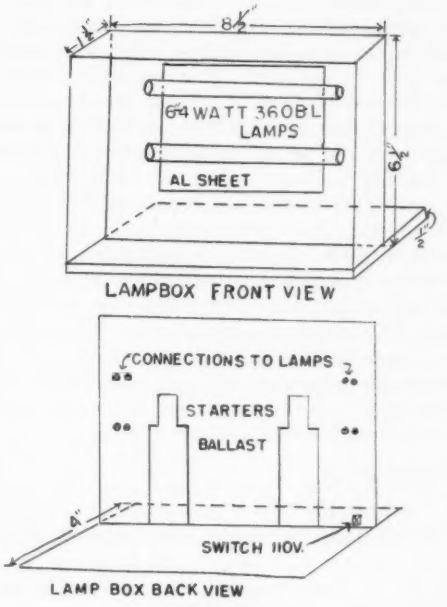


Figure 2

For those unfamiliar with the phenomenon of fluorescence and sources of ultraviolet light, a brief exposition on these topics may be desirable. The fluorescence of most substances, either in solution or as solids, is produced by exciting with wave energies between 3000 and 4000 Å. This range of wave lengths is transmitted by ordinary glass and is harmless to the eyes. Wave lengths below 3000 Å. are not transmitted by glass and are quite harmful to the eyes. Any sources of ultraviolet light generated in glass containers, such as the units described above, and high-pressure mercury-vapor lamps with glass envelopes may be used with safety. Reaction vessels used with such lamps can be of either pyrex or soft glass since both transmit the wave lengths from 3000 Å. to 4000 Å. In some few cases shorter wave lengths are required to excite the fluorescence. Examples of this are uranyl nitrate solution, scheelite mineral, and the thallous chloride-potassium chloride complex.

The low-pressure mercury-vapor lamp with a quartz or special corex-glass envelope gives a radiation especially rich at 2537 Å. This lamp must be used with a purple filter which transmits in this region and the operator must wear goggles to protect his eyes. The rays from the lamp are brought into direct contact with the object under examination or it may be placed in a quartz container.

ALUMINUM (*2, 3*)

Reagent: 4-Sulfo-2,2′-dihydroxyazonaphthalene, 0.1 per cent solution in 95 per cent alcohol (see Note below).

Procedure: After treating the hydroxides of aluminum, chromium, and iron with sodium peroxide, centrifuge the mixture and treat the decanted solution as follows: Make just acid with acetic acid using phenolphthalein as an indicator and add 1 ml. of 0.5 *N* acetic acid in excess. Add lead acetate until all of the chromate is precipitated. Filter, dilute the filtrate to 10 ml., and heat to about 80°C. in a test tube. Add about 0.5 ml. of the above reagent to the hot solution, mix by swirling, and examine under ultraviolet light. The presence of aluminum is indicated by a red fluorescence. If chromium is absent, as indicated by the absence of a yellow color after oxidation with sodium peroxide, the lead acetate is omitted but all other directions followed. The solution must be distinctly acid with acetic acid for the test. This test is sensitive to 0.1 μg. of aluminum and a dilution of one part in five million. Gallium is the only other element that gives a positive test with this reagent and the fluorescence of the gallium complex is far weaker than that of aluminum. Iron and chromium must be removed because these ions destroy the reagent by forming a precipitate.

Note: The reagent 4-sulfo-2,2′-dihydroxyazonaphthalene may be used as the acid or the sodium or zinc salt. The zinc salt is known in the dye industry as Pontachrome Blue Black R. The 0.1 per cent solution in alcohol is stable for a period of years. The solution is prepared as follows: 0.1 g. of the dye is mixed with 100 ml. of 95 per cent alcohol in a narrow-mouthed, eight-ounce bottle and heated to boiling, in a bath of boiling water, for about five minutes.

The aluminum complex which produces the fluorescence is stable indefinitely. The greatest number of errors in this test result from not having the solution acid when adding the dye reagent.

A precaution in the use of this test must be given if the Barber-Taylor laboratory procedure is used. This is the pressure-bulb method using cotton as a filter medium. If the highly alkaline medium, used for the separation of aluminum from iron, passes through cotton some of the cotton is dissolved and the resultant product interferes with the fluorescent test for aluminum. Because of the nature of the precipitate centrifugation is preferable to filtration at this point in the analysis.

ZINC (*4*)

Reagents: (1) 0.6 ml. of 35 per cent sodium silicate added to 100 ml. of 2.5 *N* NaOH. (2) 1 g. of $Na_2S_2O_4$ dissolved in 25 ml. of water (this solution must be made fresh each day and should be boiled for a minute to remove H_2S). (3) 0.3 g. of benzoin dissolved in 100 ml. of 95 per cent alcohol. (4) 0.2 g. of Mg^{++} ion as $MgCl_2$ dissolved in 100 ml. of water.

Procedure: Precipitate zinc as a sulfide as in the usual scheme. Filter, wash, and dissolve the ZnS in 1 or 2 ml. of 1 *N* HCl. Boil until all H_2S is expelled. Dilute to 10 ml. and add 1 ml. of each of the above reagents in the order given. Run a blank along with the test solution. Mix thoroughly by swirling, let stand two minutes, and examine under the ultraviolet lamp. A green fluorescence indicates the presence of zinc. This test may be made on an original unknown, provided antimony is absent, by adding NaOH until the solution is decidedly alkaline, filtering, making the filtrate nearly neutral, and adding the above reagents. It is obvious that any ions precipitating with NaOH or $Na_2S_2O_4$ must be removed before applying this test. The test is sensitive to 1 μg. of zinc at a dilution of one part in a million.

Notes: The zinc complex with benzoin is adsorbed on the magnesium hydroxide. Sodium dithionite is used to keep the benzoin from decomposing in the alkaline medium. Sodium silicate stabilizes the complex formed; without this reagent, the fluorescence can be observed for only about one-half an hour. The reaction is destroyed by hydrogen sulfide, and commercial sodium dithionite (hydrosulfite) often contains traces of hydrogen sulfide which must be removed. Beryllium and antimony are the only elements found to give a fluorescence with benzoin and both of these elements will give a fluorescence before the addition of the magnesium chloride. Antimony produces a purple-white fluorescence and the beryllium a green fluorescence.

In many texts 8-hydroxyquinoline is used to precipitate and confirm zinc. If the zinc-8-hydroxyquinolate precipitate is examined under ultraviolet light, it will be found to give a green fluorescence.

BORON (5)

Reagent: Benzoin, 0.4 per cent in 95 per cent ethyl alcohol.

Procedure: Using litmus as an indicator, make 5 ml. of the solution just basic with 0.25 *N* NaOH and add 5 drops in excess. Filter to remove any precipitate. To 1 ml. of this filtrate, add 9 ml. of 95 per cent redistilled ethyl alcohol. Add about 1 ml. of 0.4 per cent benzoin mix and observe under the ultraviolet lamp. A strong greenish-white fluorescence indicates the presence of boron. This test is sensitive to 0.2 μg. in 10 ml. or to one part in five million. Boron is the only element that responds to this test.

SODIUM

Reagent: Magnesium or zinc uranyl acetate.

Procedure: The procedure for precipitating sodium with this reagent is given in many texts. Examination of the precipitate under ultraviolet light increases the sensitivity about tenfold. The sodium zinc (or magnesium) uranyl acetate precipitate gives a greenish-yellow fluorescence.

BERYLLIUM (6, 1)

Reagent: 1-Amino-4-hydroxyanthraquinone, 0.03 per cent in 95 per cent ethyl alcohol, or 1-4-dihydroxyanthraquinone (quinizarin).

Procedure: Beryllium precipitates with aluminum in the usual qualitative separation. After the separation of chromium, as described under the aluminum test, the procedure is as follows: Make the solution just acid with HCl, and then alkaline with NH_4OH, warm, and filter. Dissolve the precipitate in 5 ml. of 1 *N* HCl; more may be used if necessary. Dilute to 20 ml. with water and use 10 ml. to confirm aluminum and the other 10 ml. for beryllium. Add 1 ml. of 10 per cent sodium citrate and 3 drops of 0.03 per cent of either of the above reagents. The solution should be a faint orange color. Add 0.25 *N* NaOH drop by drop until the solution becomes purple. Add 1 ml. more of the reagent. If the solution is not purple more NaOH should be added. (This neutralization is quite easily observed, but if the student has difficulty he should practice with a pure water solution and observe the color change of this dye from acid to basic medium.) Two more ml. of 0.25 *N* NaOH are now added and the solution observed under an ultraviolet lamp. An orange-red fluorescence indicates the presence of beryllium. This test is sensitive to 1 μg. of beryllium and to a dilution of one part in four million.

For the detection of beryllium (7) in a mineral the following procedure may be followed: A fusion mixture of 3:1 sodium carbonate-borax glass bead is formed on a platinum loop. This bead is touched to the powdered ore and fused again; it is then dissolved in 6 to 8 drops of 6 *N* HCl by placing the platinum wire and bead in the acid and warming. The procedure outlined above beginning with the sodium acetate addition should then be followed. The volume at the final addition of the reagent should be between 10 and 20 ml.

Notes: Both of the above reagents have about the same characteristics in this test and the choice is one of personal preference. Lithium is the only other element that will give a similar fluorescence to beryllium with these reagents and about 1000 μg. of lithium are required to give the same intensity of fluorescence as 1 μg. of beryllium.

Elements which form precipitates with sodium hydroxide must be removed before testing for beryllium unless they are present only in trace amounts.

THALLIUM (8)

Reagent: Potassium chloride.

Procedure: Thallous chloride precipitates in Group I of the qualitative procedure along with silver, lead, and mercury and is separated with lead by hot-water extraction. Ten ml. of 1 *N* potassium chloride is added to the solution containing lead and thallium and the beaker is placed under a source of ultraviolet light rich in short wave lengths in the vicinity of 2537 Å. A purple fluorescence indicates the presence of thallium. This test is sensitive to 1 μg. of thallium and to a concentration of five parts in ten million.

Notes: A low-pressure mercury-vapor lamp is the simplest source of the short wave lengths necessary for this fluorescence. The technique of placing the beaker containing the solution to be examined under the light avoids the use of a quartz container.

THORIUM (9)

Reagent: 1-Amino-4-hydroxyanthraquinone, 0.1 per cent in 95 per cent ethyl alcohol.

Procedure: Thorium precipitates along with iron in the common scheme of qualitative analysis as a hydroxide. To separate the thorium from iron this precipitate is dissolved in hydrochloric acid and the solution then neutralized with 10 per cent sodium carbonate and 5-ml. excess is added. This precipitates the iron and leaves the thorium in solution as a complex carbonate. To confirm the thorium, proceed as follows: Filter; wash the precipitate once with sodium carbonate and once with water.

Make the filtrate acid using concentrated nitric acid and heat it to remove the carbon dioxide. Add 10 ml. of saturated potassium iodate solution. This precipitates the thorium as an iodate. Filter; wash the precipitate once with water and then wash it into a beaker using 20 ml. of concentrated HCl. Add 7 ml. of concentrated HNO_3 and evaporate to dryness. Dissolve the residue in 10 ml. of water and add a few drops of thymol-blue indicator. In most cases this will show a pale yellow indicating a pH of about 1.75. If the

color is pink 0.1 *N* NaOH should be added drop by drop until the yellow appears. Now add 1 ml. of 10 per cent 1-amino, 4-hydroxyanthraquinone and mix by swirling. If thorium is present the solution will have a purple tinge and will give a red fluorescence under ultraviolet light. The dye will remain permanently dispersed. The dye alone, and in the presence of all other metallic ions, precipitates after a few minutes. The test is sensitive to 40 μg. of thorium and to a concentration of one part in 125,000.

Notes: Gallium and praseodymium are the only elements that give a fluorescence under these conditions. With both of these elements the solution remains red and the dye precipitates in a few minutes. Large amounts of foreign salts cannot be tolerated and in testing for thorium from highly acidic mixtures it should be precipitated with iodate as indicated above.

The precipitation of the reagent with other metals often takes place in a curious fashion. The precipitate appears to leave the walls of the test tube as a membrane-like sack which contracts slowly leaving a flocculent precipitate on top of the liquid.

CONCLUSION

No effort has been made here to describe all of the known qualitative fluorescence tests; many others are available (*10, 11*). Those given here are particularly specific, can be applied in student laboratories, and are superior to the usual color tests.

SOURCE OF CHEMICALS AND APPARATUS

Reagents

2,2′-Dihydroxyazonaphthalene-4-sulfonic acid, zinc salt (Pract.). Eastman P 6302. 100 g. $2.50.
1-Amino-4-hydroxyanthraquinone (Pract.). Eastman P 6248. 100 g. $3.
1,4-Dihydroxyanthraquinone (quinizarin). Eastman T 3054. 100 g. $1.25.
Benzoin. Eastman 302. 100 g. $1.50.
(Eastman Kodak Co., Rochester, N. Y.)

Filters

6½ inch, red-purple, molded, square. Corning 5874. $5.00.
(Corning Glass Co., Corning, N. Y.)

Lamps

1. Type to use in ordinary fluorescent balance- or desk-lamp fixture.
   6-in., 4-watt tube. 360 BL. $1.
   18-in., 15-watt tube. 360 BL. $0.87.
   (General Electric Co. or Sylvania Electric Co., 60 Boston St., Salem, Mass.)
2. Fixture, complete for 4-watt tubes.
   Lite Mite. $14.50.
   (Stocker & Yale, Dept. I. L., Marblehead, Mass.)
3. Unassembled Blacklite System with 4-watt blue tube. Cat. No. TM 1392. $3.19.
   (Herbach and Rademan, 522 Market St., Philadelphia 6, Pa.)
   or
   Blacklite Kit. $3.
   (C. & H. Sales Co., 2176 E. Colorado St., Pasadena, Calif.)
4. Mercury-vapor lamps
   (*a*) For wave lengths 3100–4000 Å.
   Hanovia Inspectolite, EH4 lamp. S. C. 5041. $49.50.
   (Hanovia Mfg. Co., Newark 5, N. J.)
   or
   Mineralight, EH4 lamp with filter. B 50. $59.50.
   (Ultraviolet Products, Inc., 145 Pasadena Ave., South Pasadena, Calif.)
   (*b*) For wave lengths at about 2537 Å.
   Mineralight. Cat. No. 41. $54.50.
   (Ultraviolet Products, Inc.)

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RARE EARTH MNEMONIC AID

The following was brought to the Editor's attention recently as a means of remembering the order of the rare earth elements. The symbols of the elements are italicized.

Lancer prince needs 61 small European gods to be dyed wholly, early tomorrow. Why be ludicrous?

EVALUATION OF ACHIEVEMENT IN CHEMISTRY[1]

MAX D. ENGELHART
Chicago Public Schools, Chicago, Illinois

It is generally accepted that effective instruction in chemistry involves more than the imparting of the content of a text. While acquisition of knowledge of facts and principles is a major objective of chemistry instruction, other important objectives should not be neglected. These include the ability to apply facts and principles to problems requiring abstract or critical thinking and the attainment of desirable attitudes, ideals, and interests. Laboratory instruction, in addition to developing numerous manipulative skills, should also contribute to the acquisition of all of the objectives referred to above. Where teaching is restricted to the imparting of knowledge and no serious effort is made toward the attainment of a broader range of objectives, there is little justification for use of tests containing other than factual essay or objective exercises. It is the purpose of the author to offer suggestions which should prove useful to teachers of chemistry interested in the evaluation of a comprehensive range of objectives.

Knowledge of facts and principles can be evaluated by means of either essay or objective exercises. It is more efficient, however, to measure the acquisition and retention of knowledge by means of the latter. Since many more objective exercises than essay ones can be answered in a given time, it is possible to secure much more representative sampling of knowledge by using objective exercises. Furthermore, because of the greater number of exercises and the objectivity of scoring, the reliability of the measurement is usually higher. When essay questions are used they should be confined to thought questions. They should not be too specific and detailed in character. An essay question which asks the chemistry student to describe the operation of a blast furnace with respect to: (*a*) the charge of limestone, coke, iron ore, and hot air; (*b*) the combustion of carbon to carbon dioxide, the reduction of carbon dioxide to carbon monoxide, and the reduction of iron oxide by carbon monoxide to iron; and (*c*) the function of limestone as a flux or slagging agent, gives the student little freedom with respect to what to say and how to say it. A mere request to describe the operation of a blast furnace should stimulate not only recall of facts, but also discriminative thinking in the selection of facts and greater effort and originality in organizing them.

It is often effective to use essay questions which ask the student to compare or contrast. For example, "Compare respiration in the living cells of plants and animals with ordinary combustion" and "Contrast the formation of compounds by electron sharing with the formation of compounds by electron transfer." Such questions are most likely to stimulate thinking on the part of the student, if instruction, though covering the things contrasted or compared, has not involved point by point comparisons, or contrasts.

Sometimes it is possible to formulate essay questions which involve applications of general principles to situations or problems novel to the student. For example, suppose that a class has been taught the principle of the activity series of metals and that the more usual applications have been given. Then, at some later time, an essay test may include the question: "A photographic print contains fine grains of silver. Explain why immersion of such a print in gold chloride solution will result in a different appearance or tone." Other possibilities for good essay questions of this type can be based on descriptions of experimental data, novel to the student, but having relations analogous to data with which he has had experience. Sometimes the data thus presented can be accompanied by inferences drawn from them which the student is asked to evaluate or to criticize.

In addition to essay questions of the kinds referred to above it would seem appropriate to frame some which have to do with the place of chemistry in contemporary life. Such questions may be of great value in integrating the teaching of chemistry with instruction in other fields. For example, "Compare the possible consequences of the introduction of atomic energy in industry with the consequences which resulted from the introduction of coal as a source of power" or "Discuss the contribution of the science of chemistry to the health of the community." Questions asking for the interpretation of data novel to the student, or which are of the type referred to in this paragraph, not only provide the instructor with bases for judgments with respect to the thought patterns of the students, they also provide the instructor with opportunities to evaluate the acquisition of attitudes, ideals, and interests. Careful analysis of the responses of the students should provide answers to such questions as the following: To what extent is the student able to recall, select, and evaluate relevant facts? To what extent is the student able to organize his facts and to apply them to the situation represented by the question? To what extent is the response of the student colored by biases or prejudices? To what extent does the student exhibit

[1] Based on a paper presented at the 118th Meeting of the American Chemical Society, Chicago, September, 1950.

critical judgment with respect to the facts he mentions? Does the student tend to go beyond the facts, or is he overcautious in generalizing? What attitudes or values is the student acquiring? The responses of the students may be rated with respect to such characteristics and the ratings combined to yield scores on the essay test as a whole. More important, however, than using such testing as one means of determining course marks is to use it as a means of evaluating the attainment of important course objectives and as a basis for the better direction of the instruction to the individual students immediately concerned.[2]

Before turning our attention to the writing of objective exercises some reference should be made of the contribution essay examining can make to the proper education of science and engineering majors. Responsibility for giving such students training in the writing of reports of research cannot wholly be left to English teachers. Such students need experiences in the locating of published information concerning scientific problems. They need practice in evaluating the relevance of such information. They need to acquire something of Darwin's attitude toward data which disagree with a hypothesis tentatively held to be true. They need to acquire ideals with respect to the importance of accuracy in taking notes and in citation of sources. Finally, they need to acquire facility in organizing and summarizing what they have read. The providing of such experiences may be a means of enriching the curriculum for the superior student, of securing greater motivation through the challenge to his abilities, and of increasing his interests in the field of chemistry.

Facts, concepts, or understandings essential to effective thinking in chemistry should form the basis for numerous objective exercises. Before writing an exercise relevant to some fact, consideration should be given to the importance of the fact. Is it a fact that the student needs to know if he is to comprehend later instruction? Is it a fact necessary to the solution of some important problem? Does it enhance understanding of some basic principle? After such facts or concepts have been identified, one or more types of objective exercises may be written. Each series of exercises, however, should consist of items of the same type to avoid confusion with respect to directions.

If you feel that you must write true-false exercises, avoid writing broad generalizations which are all too obviously true or false. Avoid also the writing of long, involved statements containing qualifying phrases. Test-wise students realize that such statements are usually true. Furthermore, the truth or falsity of a true-false exercise should not depend on the meaning of some obscure word or minor detail. One means of improving true-false exercises is to use such categories as the following in the directions which precede the items:

> On the blank preceding each of the following sentences, write the letter
> *A* if the statement is true, and its truth is supported by the reason given.
> *B* if the statement is true, but its truth is not supported by the reason given.
> *C* if the statement itself is false.

(B) Barium is a more active element than calcium, because it has a smaller atomic radius.

(A) Ionic compounds generally have higher melting points than non-ionic compounds, because the ions are held together by strong electrostatic forces.

(C) Calcium carbonate dissolves more rapidly in pure water than in water containing carbonic acid, because carbonate ions will cause the precipitation of calcium ions through formation of calcium carbonate.

Multiple-choice exercises containing four or five answers, one of which is correct, are a standard type of objective exercise. Such exercises may begin with a question, or the introductory part of the exercise may be the beginning of a sentence grammatically completed by *each* of the answers. In either case, the initial part should set the problem of the exercise. Do not begin such an exercise with, "The law of multiple proportions is. . ." and conclude with five long answers, one of which is the correct definition of this law. It is better to begin the exercise with a correct statement of the law and then use the names of several laws including the law of multiple proportions as one of the answers. Other precautions in the writing of multiple-choice exercises include the formulation of none but reasonably plausible incorrect answers, the listing of answers in columns for easy reading where the answers are longer than single words or very brief phrases, and the avoidance of so phrasing the correct answers that they are most often the longest answers. Below are given a number of multiple-choice exercises:

(D) The discovery *most* crucial to the development of the atom bomb was the discovery that
- A. isotopes of uranium exist.
- B. uranium is a radioactive element.
- C. the rate of disintegration of certain types of atoms is extremely rapid.
- D. slow moving neutrons can split atoms of uranium.
- E. isotopes can be produced by bombardment of atoms with alpha particles.

(C) Gasoline, a mixture of hydrocarbons, burns to carbon dioxide and water. In order to maintain a dirigible, or lighter than air, airship, at a constant weight, the procedure used is to condense water vapor present in the exhaust gases from the engines and allow the CO_2 to escape. However, only about 70 per cent of the water vapor need be condensed. Why?
- A. Water is denser than gasoline.
- B. Dirigibles filled with helium are heavier than those filled with hydrogen.
- C. The water contains oxygen from the atmosphere.
- D. Gasoline is about 70 per cent carbon.

(B) In balancing the equation $Al(OH)_3 + H_2SO_4 \rightarrow Al_2(SO_4)_3 +$

[2] For a more extended discussion of these points of view with respect to essay testing see: VERNER M. SIMS, "The essay examination is a projective technique," *Educational and Psychological Measurement*, **8**, 15–31 (Spring, 1948).

H_2O small numbers need to be written before the formulas, although the number 1 is usually omitted. Supposing that it is not omitted in this case, the four numbers are

A. 1, 3, 1, 3.
B. 2, 3, 1, 6.
C. 1, 3, 2, 6.
D. 2, 3, 1, 3.
E. 3, 2, 1, 3.

(C) Ten grams of $KClO_3$ and 2 grams of MnO_2 are heated in a flask and the oxygen produced is weighed. Given 39 as the atomic weight of potassium, 35.5 as the atomic weight of chlorine, 16 as the atomic weight of oxygen, and 55 as the atomic weight of manganese, what weight of oxygen is produced?

A. Almost 2 grams.
B. Slightly more than 3 grams.
C. Almost 4 grams.
D. Slightly more than 4 grams.
E. Approximately 5 grams.

Certain comments may be made with respect to each of the above exercises. All of the answers to the first of the four exercises represent discoveries of importance to the development of the atom bomb. More than knowledge of facts is required in selecting "D" as the correct answer. The student must evaluate the significance of each of the discoveries. The second exercise represents the application of a presumably well-known principle to a novel problem. Its value in measuring skill in thinking would, of course, be lost if the instructor has described this means of maintaining the constant weight of a dirigible in discussing combustion. The third exercise suggests a device which should prove useful in testing objectively the ability of the students to balance equations. The fourth exercise is a typical chemistry problem in objective form. Giving the answers as approximations may stimulate the student to compute the answer rather than to attempt to work back from more precisely stated answers. It is often effective in series of quantitative problem exercises to give as answer "E," "none of the above answers." When this is done answers A, B, C, and D should not be approximate answers since the student can then argue that the exercise has two correct answers. When the answer "none of the above answers" is used in a series of exercises, it should sometimes be the correct answer.

Many teachers have difficulty in writing the directions which precede series of objective exercises. Such directions should be simple. In the case of multiple-choice exercises in which students are to record their answers on blanks preceding the exercises, the following statement should suffice. "On the blank preceding each of the following exercises write the letter which designates the correct answer." If a hand-scored answer sheet is used, the exercises throughout the test should be numbered consecutively. Then the above directions may be modified as follows: "After the number on the answer sheet which corresponds to that of each of the following exercises, place a cross (X) in the one lettered square which designates the correct answer."[3] In the case of machine-scored answer sheets instead of stating "place a cross (X). . ." say "blacken the one lettered space which designates the correct answer."

The testing of knowledge of the meanings of important terms is often effectively accomplished by means of matching exercises. A series of definitions may be given accompanied by a list of the terms defined. Usually the number of terms listed should be greater than the number of definitions given. The definitions should concern terms likely to be confused by the student whose knowledge is inadequate and the extra terms should not be obviously out of place in the list. All terms may be listed in alphabetical order to aid the student and neither the list of definitions nor the list of terms should be too long. Twelve definitions and fifteen to eighteen terms are reasonable numbers. When hand-scoring or machine-scoring is used, groups of three definitions and five terms should be given. For example:

(E) 187. The process in which electrons are gained in the outermost orbit of the atoms of the element.

(C) 188. The process in which the hydrogen and hydroxyl ions in solution unite to form water, and the other ions unite to form a salt.

(D) 189. The process in which electrons are lost from the outermost orbit of the atoms of the element.

A. Hydrogenation
B. Ionization
C. Neutralization
D. Oxidation
E. Reduction

Each group of such exercises is set off by a horizontal line, and in each such group the terms are labeled from A to E.

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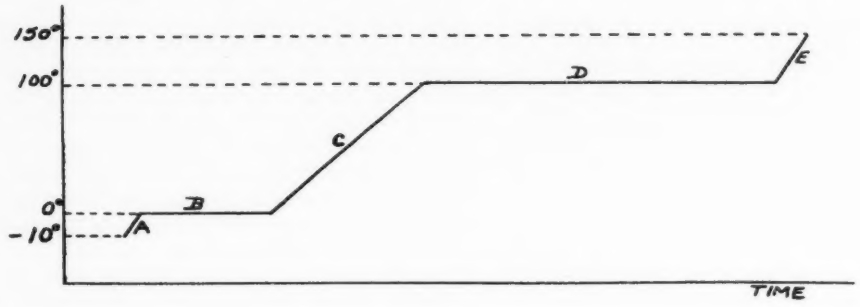
[3] When an answer sheet is prepared for rapid hand-scoring in which answer sheet numbers are followed by lettered squares, for example,

	A	B	C	D	E
123.	□	□	□	□	□

scoring stencils can be made easily by preparing a keyed answer sheet and punching holes in the spaces which represent the correct answers. An IBM punch is the most convenient device to use, since it will reach anywhere into an $8\frac{1}{2} \times 11$-in. page. The preparation of exercises for hand-scored answer sheets is an effective means of developing test materials which will later prove well adapted to machine-scoring. A final suggestion or two may be made with respect to the hand-scored answer sheet. The letters A, B, C, D, and E need not appear above each group of five squares. It is sufficient that they appear at the top of each column. Provide labeled blanks at the top of the sheet for name, course, and date. An attractive hand-scored answer sheet may be typewritten on good bond paper whose dimensions are 10 × 13 in., the squares may be drawn in India ink using a ruling pen, and the manuscript reproduced in quantity by planographing or lithoprinting. In printing, the sheet is reduced to $8\frac{1}{2} \times 11$ in. Such a sheet may contain groups of squares numbered from 1 to 150.

In the case of true-false exercises, the students should record their answers in lettered spaces A and B.

A gram of ice at -10°C. is heated to steam at 150°C. The heat is supplied at a uniform rate of one calorie per second. The graph below shows the relationship between temperature and time during the course of this experiment. After each exercise number on the answer sheet, blacken the one lettered space indicating the part of the graph to which the item correctly refers. (The specific heats of ice and of steam are .53 and .47 respectively.)



(B) 97. Both ice and water are present.

(E) 98. Approximately 23 calories of heat are absorbed.

(D) 99. Both water and steam are present.

(C) 100. Along this line each calorie of heat absorbed changes the temperature one degree.

Figure 1

When the students record their answers in the test booklet, precede the series of exercises by the statement: "On the blank preceding each of the following items, write the letter which designates the term at the right to which the item correctly refers." In the case of hand-scored answer sheets say, "After the number on the answer sheet which corresponds to that of each of the following items, place a cross (X) in the one lettered space which designates the term at the right to which the item correctly refers." In the case of machine-scored answer sheets substitute the phrase "blacken the one lettered space."

A very useful general type of objective exercise involves the classification of items according to a limited number of categories. When answer sheets are used the number of categories should not exceed five, and, in any case, five categories are about all a student should be expected to keep in mind. The categories may pertain to related, but different things. There should be one or more items to be classified according to each category. As in the case of multiple-choice exercises and matching exercises, if relationships exist between the various answers or items more is evaluated than sheer memory of information. The student is required to do discriminative thinking in selecting the correct answers. Examples of several different types are given below.

After the number on the answer sheet which corresponds to that of each of the following paired items, blacken space

A if the item at the left is greater than the item at the right.
B if the item at the right is greater than the item at the left.
C if the two items are of equal magnitude.

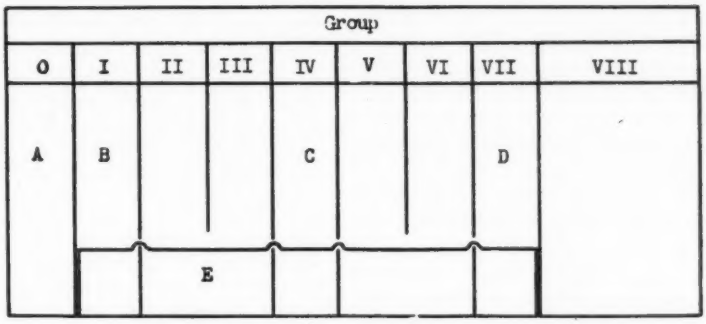
(C)	110.	Number of electrons lost at the cathode in a voltaic cell.	Number of electrons gained at the anode of the same cell.
(B)	111.	The tendency of saturated hydrocarbons to react with bromine.	The tendency of unsaturated hydrocarbons to react with bromine.
(A)	112.	The tendency of carbon to form covalent compounds.	The tendency of aluminum to form covalent compounds.

After the number on the answer sheet corresponding to that of each of the following paired items, blacken space

A if the two things referred to tend to increase together, or to decrease together.
B if, while one of the two things tends to increase, the other tends to decrease.
C if one of the two things tends to remain constant while the other increases or decreases.

(A)	185.	The number of carbon atoms in an organic compound. The number of isomers of the organic compound.
(C)	186.	The number of molecules of a gas in a given container at 760 mm. and 0°C. The molecular weight of the gas.
(B)	187.	The mass of a gaseous ion of a given charge. The bending of the path of the ion in a magnetic field.

The following diagram represents, in skeleton form, the periodic table. Certain areas of the table are labeled A, B, C, D, and E. After the number on the answer sheet corresponding to that of each statement, blacken the one lettered space indicating the area in the table to which the statement correctly refers. (Area E extends across the bottom of the table overlapping the lowest parts of areas B, C, and D.)



(D) 203. **The elements near the top of this area are the strongest oxidizing agents.**

(A) 204. **The outer shells of the atoms of these elements, with one exception, always contain eight electrons.**

(E) 205. **In this area one finds most of the naturally occurring radioactive elements.**

(B) 206. **The elements near the bottom of this area are the strongest reducing agents.**

(C) 207. **The formation of compounds by elements near the top of this area is characterized by electron sharing.**

Figure 2

After each item number on the answer sheet, blacken space
A if the item refers to the electron.
B if the item refers to the alpha particle.
C if the item refers to the deuteron.
D if the item refers to the positron.
E if the item refers to the proton.

(E) 154. Has unit mass and unit positive charge.
(B) 155. Has a mass of four and a charge of plus two.
(A) 156. Is sometimes called a beta particle.
(C) 157. Is the nucleus of the heavy hydrogen atom.
(D) 158. Has a mass of approximately $^1/_{1850}$ that of the hydrogen atom and unit positive charge.
(A) 159. Has a mass of approximately $^1/_{1850}$ that of the hydrogen atom and unit negative charge.

After each item number on the answer sheet, blacken space
A if the item is true of metals.
B if the item is true of nonmetals.
C if the item is true of both.
D if the item is true of neither.

(C) 146. Combine chemically by gaining or losing electrons.
(A) 147. Their oxides form alkaline solutions when dissolved in water.
(B) 148. Many are gases or have low melting solids.
(D) 149. Are chemically inert and form no compounds.
(B) 150. They combine readily with elements of Group I of the periodic table.

The directions given above pertain to machine-scored answer sheets. In the case of hand-scored answer sheets substitute the phrase "place a cross (X) in lettered space" for the phrase "blacken space." It should be evident to the reader that there are numerous possibilities in the field of chemistry for various types of classification exercises. The categories of the first example could be used for a vast number of paired comparisons. The categories of the second example could be used to test knowledge of numerous cause and effect relationships. (It is usually best to give the cause first when writing each pair.) The five categories of the third example could pertain to five typical organic compounds represented by their structural formulas. The categories of the fourth example could pertain to "ionic compounds," "non-ionic compounds," "both," and "neither." When writing classification exercises of the types described, be sure that there is at least one item for each category and that there are more items than categories.

Multiple-choice exercises may refer to various parts of a diagram. When the number of parts is no greater than five and these are labeled from A to E, items may be classified in terms of these labels. Two examples are given (Figures 1 and 2).

The following directions are useful in writing classification exercises which pertain to quoted material (a paragraph or two, or even a graph). Such exercises are particularly valuable in the evaluation of the ability of students to interpret data.

Making your judgments only in terms of the information given above, classify each of the following items by blackening space

A if the item is *definitely true.*
B if the item is *probably true.*
C if the item is *definitely false.*
D if the item is *probably false.*
E if the information given is not sufficient to indicate any degree of truth or falsity in the item.

Probably-true statements are justifiable interpolations, extrapolations, or predictions from the information or data given. They may represent legitimate generalizations from information describing a sample or deductions with respect to a sample where the information pertains to things in general. Probably-false statements are unjustifiable interpolations, extrapolations, predictions, or generalizations.

Such exercises may be scored not only to determine the general accuracy of the students in interpreting data, but also to identify students who have tendencies to be overcautious, to go beyond the data, or to make crude errors of judgment.

Exercises of this type are very appropriate in achievement tests. Since the facts needed in thinking are presented in the quoted material, it seems legitimate to attribute differences in the scores of the students to differences in their ability to think in the subject-matter field. Where the quoted material is novel, or is on a level above that encountered in the course, the scores may be useful as predictions of future success in the field.

In concluding this discussion of various types of objective exercises, the importance of careful evaluation and editing of exercises prior to use should be stressed. After exercises have been written they should be carefully checked for accuracy of phraseology and correctness of the key. It is very desirable to have other teachers of the subject evaluate the exercises with respect to fairness, freedom from ambiguities, and elimination of the too obviously incorrect answers. It is also an excellent practice to have other teachers attempt to key the exercises. When teachers respond differently to an exercise, faults may be identified of which the writer of the exercise was unaware. After an objective test has been given, item analysis is a procedure useful both in evaluation of the attainment of objectives and in identifying exercises which need improvement before being used again, or which should be eliminated. A simple type of such analysis has been described by the author[4] and a more complex, but more adequate, type by Davis.[5]

In discussing essay exercises mention was made of the possibility of reading student responses to gain insight with respect to attitudes and values. The author knows of no effort in the field of chemistry to use objective instruments for this purpose. In the social studies, attitudes have been evaluated by scales which include series of statements to be marked by the student: "A" if the student agrees, "D" if he disagrees, and "U" if he is uncertain. (A, B, and C can be used with a standard answer sheet.) Three such statements are given below from the "Scale of Beliefs" of the Eight-Year Study of the Progressive Education Association[6]:

Complete freedom of speech should be given to all groups and all individuals regardless of how radical their political views are.
Public regulation of business and industry is necessary in order to protect the general public.
Strict immigration laws should be passed so as to keep America for Americans only.

The scale yields a "liberal" score, a "conservative" score, and an "uncertainty" score for the scale as a whole. One can also obtain similar scores for the groups of items relevant to "democracy," "economic relationships," "labor and unemployment," "nationalism," "race," and "militarism." The magnitude of the uncertainty score is an index of strength of convictions. In a more recent scale, two types of uncertainty scores were obtained—"warranted" uncertainty and "unwarranted" uncertainty. In addition to obtaining the scores referred to above it is valuable to secure counts for each item of the numbers or per cent of students who agree, who disagree, and who are uncertain. Such analyses of the responses to attitude scales given at the beginning and end of a course can be very useful in evaluating what changes in attitudes and beliefs have resulted from instruction. The scores or analyses should not be factors in determining course marks if students are to feel free to give honest answers. Possibly, someone will be interested in constructing a similar attitude scale in chemistry.

Another means of evaluating attitudes is by means of rating scales. For example, suppose that several attitudes have been defined and that the instructor wishes to rate his students with respect to them according to a five-point scale. Suppose further that one of the attitudes is "scientific attitude," then the scale dealing with this attitude may be as follows:

Is eager to obtain new ideas or to formulate hypotheses, but invariably suspends judgment with respect to them until evidence has been obtained and evaluated.	5 points
Is receptive to new ideas or hypotheses and shows willingness to suspend judgment on numerous occasions, but is sometimes reluctant to seek necessary data or consider alternative hypotheses.	4 points
Is passive with respect to new ideas or hypotheses and shows only occasional willingness to suspend judgment or to seek necessary data.	3 points
Preconceived ideas and prejudices usually preclude acceptance of new ideas or hypotheses even when evidence adequate to support them is provided.	2 points
Always clings to his own ideas and is actively intolerant toward evidence disproving them, or which adequately supports opposing ideas or hypotheses.	1 point

[4] ENGELHART, MAX D., "How teachers can improve their tests," *Educational and Psychological Measurement*, **4**, 109–24 (1944).

[5] DAVIS, FREDERICK B., "Item Analysis Data, Their Computation, Interpretation, and Use in Test Construction," Harvard Education Papers Number 2, Harvard Graduate School of Education, Cambridge, Massachusetts, **1946**. (42 pp.)

[6] SMITH, EUGENE R., RALPH W. TYLER, and the Evaluation Staff, "Appraising and Recording Student Progress," Harper and Bros., New York, **1942**, p. 550.

Ratings by means of such scales[7] are, of course, subjective, but they are not as subjective as judgments unaided by such devices. The defining of various levels of the possession of such traits promotes consistency in the judgments made from one student to another. Where the scale pertains to several different attitudes or other traits, there is greater control of the "halo" effect. Judgment with respect to one trait is less likely to prejudice judgment with respect to other characteristics of the same individual. In addition to the rating of attitudes this type of evaluation might well be extended to the measurement of laboratory skills. For a given skill one could write five definitions representing varying levels of the possession of the given skill. These definitions should pertain to readily observable characteristics of behavior, or products of behavior, for example, characteristics of the apparatus set up by a student for the performance of a given experiment or limits of accuracy in analyzing some unknown in quantitative analysis.

The author has made a number of suggestions with respect to evaluation of the attainment of a variety of objectives. In concluding this discussion of testing in the field of chemistry it should be emphasized that improvement of instruction and improvement of evaluation have a reciprocal relationship, each depending upon the other. Given adequate definition of objectives and instruction guided by them, adequate evaluation is facilitated. Given effort to improve evaluation as suggested above leads to further improvement of instruction, since teachers may thus obtain data valuable in the more adequate direction of instruction.

[7] A number of similar scales are reported in E. R. SMITH, R. W. TYLER, and the Evaluation staff, *op. cit.*, pp. 477–82. The scale given is a modification by the writer of their rating scale for "open-mindedness."

IT'S YOUR DIVISION

DIVISION OF CHEMICAL EDUCATION
of the American Chemical Society

HUNDREDS of movies on chemical subjects are now available for showing to classes at minimal expense to the exhibitor. Many of these have been listed in the publication, "Films on Chemical Subjects" put out by the National Office of the American Chemical Society. Yet it is the universal opinion that the vast majority of these films leaves a great deal to be desired when used for classroom purposes. For one thing, the exhibitor does not know until he views the film just what its contents are. He is, therefore, hesitant to send for too many new films. A large step in the direction of overcoming this handicap is being taken by Professors Sanderson and Wistar [J. CHEM. EDUC., **27**, 488 (1950)]. They are preparing a series of descriptions of some of the more popular films so that it will be possible for those unfamiliar with the films to order what they wish to see with more selectivity.

The common objection still remains that most films were not designed for class use. They are too long. They contain too much extraneous material. They leave out certain items which would very greatly increase their worth for school use. As a step in helping to solve this problem the Executive Committee of the Division of Chemical Education has suggested that a committee be set up to edit these films in cooperation with their producers with particular emphasis on the ultimate utilization of the films in the teaching of chemistry. The initial step would be to approach producers of films which are already quite good and well accepted and which would require a minimum of change to maximize their benefit to the student. Such edited films would then be listed with a complete description. The ultimate goal would be to have a rather wide selection of films all of which had been particularly aimed at the chemistry student. The intent is to keep the movies under 15 minutes in length in order to make it easier to show as many of them as possible.

It has been further suggested that as each of the films is edited it be given a showing at the national meetings of the Division and be given adequate advertisement in THIS JOURNAL so that teachers will be familiar with its contents and worth.

Several excellent movies have already been suggested as ones with which the program might well commence but further suggestions would be welcomed as well as comments on the potentialities of the program and methods of making it most productive of useful films. Your contributions are actively solicited and should be sent to the Chairman of the Division of Chemical Education, Department of Chemistry, Oberlin College, Oberlin, Ohio.

For maximum success the program needs as broad a base as possible of active participants. Let's hear from you.

J. A. CAMPBELL, *Chairman*

AN ISOTHERMAL BALANCE CHAMBER

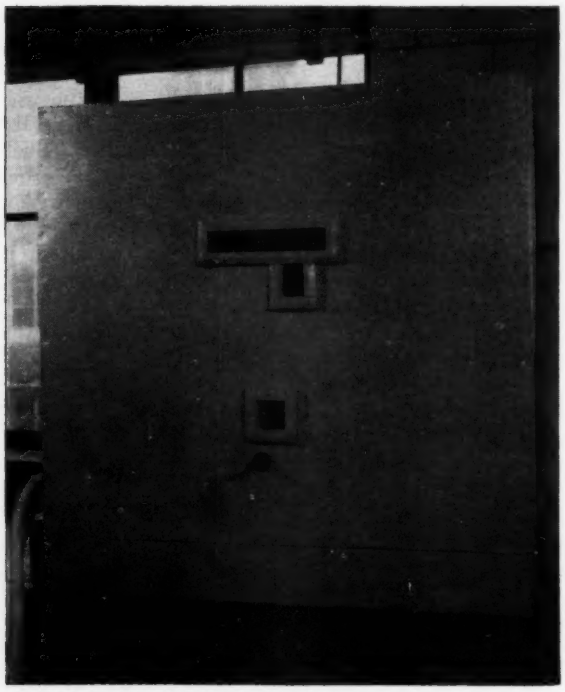
WILLIAM S. CASTOR, JR.[1] **and FRED BASOLO**
Northwestern University, Evanston, Illinois

MAINTENANCE of an analytical balance at constant temperature for extended periods of time is a problem rather frequently encountered. An isothermal balance can be obtained by mounting the instrument in one of the commercially available incubators; however, this is not always practicable for either structural or economic reasons. The former difficulties arise from the consideration that extensions must be fitted to the balance controls, to permit weighing operations without disturbing the thermal condition. Precise temperature control of the balance proper is frequently avoided by the use of a torsion balance external to the chamber containing the weighed sample; however, this technique is not always desirable. The photographs show an inexpensive, readily constructed chamber suitable for maintaining a balance at a temperature within 5° to 10°C. of room temperature, with a tolerance of ±0.1°C.

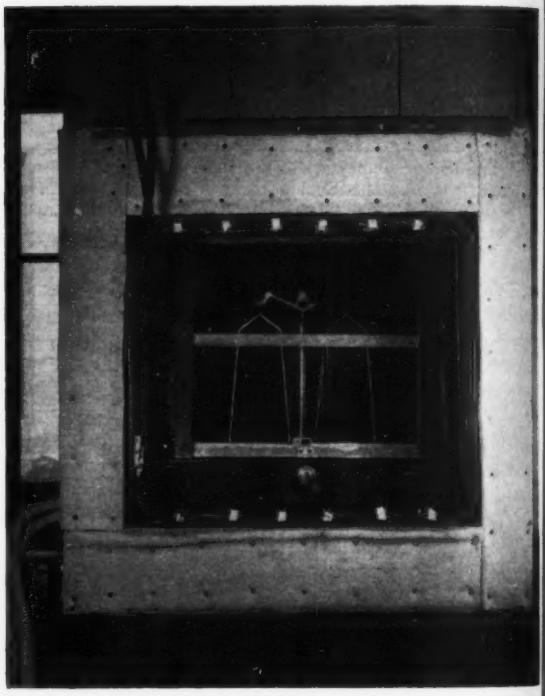
The chamber is essentially a double-walled box constructed of scrap lumber or crating. The larger cracks were filled with a plastic roof coating, and the wood was then sealed with a liquid asphalt roof coating applied to the surfaces facing the intrawall space. Blocks were inserted between the walls at points where holes were to be drilled, and the intrawall space filled with a commercial "pouring" insulation. Gray porch paint was used on the external surfaces of the chamber illustrated. The interior was tarred; but this did not prove very satisfactory, so black paint was substituted in a second, larger box of the same type. Several thicknesses of woolen cloth were tacked to the front edge to serve as padding between box and door.

Windows were provided in the door for observation of the beam, vernier, and pointer scale of the Ainsworth LCB balance used. This type of balance was chosen from those at hand because all chain readings are made at one place. Windows were double-walled and of glass or celluloid. The door was hinged at the top so that extensions to the pan- and beam-arrest controls did not have to be removed to open or close the chamber. Six 6-volt d.-c. bulbs in parallel were mounted symmetrically near the interior front and bottom edges of the box

[1] Present address: American Cyanamid Company, Calco Chemical Division, Piney River, Virginia.



Closed Chamber Showing Windows and Controls Required for Balance Operation



Open Chamber Showing Details of Construction

to provide the light necessary for weighing observations. They were shut off when not needed; leaving them on for prolonged periods caused an increase in temperature.

Temperature control was obtained by cycling water from a constant-temperature bath through about 200 feet of 1/4-inch soft copper tubing nailed to the interior walls of the insulated chamber. That on the inside of the door was joined to the rest by rubber tubing. External tubing was wrapped with asbestos cord. To avoid the formation of vapor locks during the initial filling, one end of the tubing was attached to an aspirator and the other to the tap. After partial evacuation, the tap was opened. Thereafter, no circulation difficulties were experienced with good laboratory centrifugal pumps.

Extensions for the chain-weighing device and rider arm were brass rods of appropriate size attached with set-screw collars. The beam-arrest extension was a brass tube welded to a collar which fitted over the original knob and was fixed in place with set screws. A rod ran through it and was screwed to the threaded shaft from the pan-arrest control. The original wheel or knob was then affixed to each rod.

To permit opening of the balance case without its removal from the isothermal chamber, the glass door was replaced by one of celluloid. This could be rolled back over the top of the case. The balance was leveled with the aid of a small mirror. For our purposes it was desirable to desiccate the balance case. In order to do so efficiently, the door was sealed to the case with a plastic calking cord which was easily applied and removed.

A larger chamber of similar construction was fitted with removable shelves. It served very satisfactorily as a desiccator box for the storage of samples being dried to constant composition in various hygrostats.

JOHAN ARVID HEDVALL

RALPH E. OESPER
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Corpora non agunt nisi fluida, a dictum that probably came down from Aristotle, was generally accepted until well into the twentieth century. It has now been disproved, and especially by J. Arvid Hedvall. This eminent chemist was born at Skara, Sweden, on January 18, 1888. His training was received primarily at the University of Upsala, where he was assistant in meteorology (1909–1912) and then in chemistry (1912–1915). After a period of further study at Göttingen (1916) he carried on industrial research (catalysis) at the metallurgical works at Falun. From 1918 to 1927, he was lecturer at the Technical High School in Örebro, and from 1927 to 1946 he was professor of chemical technology at Chalmers University of Technology in Göteborg. Since 1946 Dr. Hedvall has been director of the Swedish Research Institute for Silica Chemistry, which was erected for him at Göteborg by the state in cooperation with the industries.

He was the first to demonstrate the fallacy of the Aristotelian declaration, and proved the possibility of reactions between solids in general. The start of this important advance is found in his doctoral thesis (1915): "On the reaction products between cobalt oxides and other metal oxides." In conjunction with about 150 collaborators in all he has since made systematic investigations of the reactivity of solids and its dependence on various factors, such as transition states, magnetism, electrical polarization, and irradiation. These influences, whose existence was established for the first time in most cases, have widened and deepened the scope of magneto-, electro-, photo-, and phonochemistry.

A new area, known as mineralography, was thus founded and worked out, with concurrent enrichment of the older metallography. The findings have been applied to all sorts of technical processes involving solid substances, especially many branches of silica chemistry, metallurgy, and industries employing catalysts. The restoration of museum specimens, cultural monuments, and buildings has profited from this research. The great effect exerted by dissolved gases on the reactivity of all sorts of solid solvents (known previously only for metals) has been demonstrated and its importance thus emphasized. An excellent compilation and discussion of this new knowledge is given in Hedvall's book, "Reaktionsfähigkeit fester Stoffe" (Leipzig, 1938; reprinted, Ann Arbor, 1943).

Professor Hedvall holds membership in various academies of science, and has received honorary degrees. He has lectured by invitation in most European countries, Turkey, Palestine, and the United States. He holds the Björken Prize (Upsala); the Göteborg Medal for Civil Merits; the Gauss Medal of the Brunswick Society of Science.

UNDERGRADUATE RESEARCH[1]

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INCREASED interest in chemistry, medicine, atomic energy, and scientific research generally, has brought to the front the significant role of science in our civilization. Just what importance the role of science, particularly chemistry, should assume in the educational program is causing educators much concern. Specialized training is usually obtained through advanced study and research. Just how much of this should be given in a liberal education is a controversial subject.

Of those entering the profession of chemistry each year, about eight per cent have the doctor's degree, and another eight to ten per cent the master's; the significant fact, however, is that about 80 per cent enter with only the bachelor's degree.[2] This would indicate that for the great majority of chemists, training for the profession is the responsibility of undergraduate education. How much, if any, research or independent study should be included in this education?

The author was interested in finding out what percentage of colleges and universities offer a course in undergraduate research and accordingly sent a questionnaire to 110 institutions of all types: small colleges and large universities, liberal-arts colleges and technical schools, etc. The selection of institutions geographically and educationally was such that it was felt that the reactions obtained would present a fairly representative picture of the attitude toward undergraduate research.

The major questions asked were:

1. Is an undergraduate research program offered?
2. Is your attitude toward undergraduate research favorable or unfavorable, and why?
3. What requirements do you consider necessary for adequate undergraduate research?
4. What benefits to the student and institution result from such a program?

Out of 86 replies, 68 favored undergraduate research in the curriculum, 12 did not, with 6 undecided. Sixty-three offered such a program, while 23 did not. Of the latter group, 7 favored such a course, however. Of those offering undergraduate research, three were undecided as to its suitability. Many had modified the courses originally offered. Eleven of the research courses were required, the rest optional. Forty-one were reported as being limited to senior students, while eight were also open to juniors. The general attitude is shown to be five to one in favor of undergraduate research in the curriculum. In the majority of cases, no significant difference could be seen between different types of institutions; however, several required a senior thesis before graduation.

There has been a great deal of discussion regarding the place of science in liberal-arts education,[3] and an ever-increasing demand that students in college be broadly educated, leaving little time for specialization. However, when the four-year student enters industry to earn a living he soon finds that the jack-of-all-trades graduate is very likely to become tied to the bench because he has had little of this specialized training. In this scientific age it seems that the student must be both liberally educated and specialized if he is to compete with students having graduate degrees or technical-school training.

The American Chemical Society has attempted through the Committee on Professional Training to set up criteria for the "balanced" education of a chemist. Courses in liberal arts are listed along with the basic courses in chemistry and some degree of specialization. This specialization is usually in the form of an advanced course, or courses, in one of the major branches of chemistry; however, some members of the Committee feel that a program of research is indispensable to a small college but should not replace work in the basic year courses required by the A. C. S. Minimum Standards, such as organic and physical chemistry. This is concurred in by those institutions offering undergraduate research.

The chief objection to undergraduate research found in this survey was that so much time has to be spent in teaching basic principles, that there is no time left for attention to undergraduate research. This objection was met with the question, "How is an instructor to judge whether or not a student has grasped the basic principles?" The simple fact that information is funneled down a student and he can parrot this information back is no assurance that he understands what he is doing.

The majority of the institutions favoring some form of independent study feel that a student who has shown sufficient interest and grasp of fundamentals should be given the opportunity for independent work. Sometimes students who are just average in class work will show unusual talent when started on an independent project.

However, care must be taken in the selection of the extent or scope of the problem. It should be of such a nature that the student gets a taste of the difficulties of research, but at the same time accomplishes enough to gain a feeling of achievement and a realization of the

[1] Presented at the 118th Meeting of the American Chemical Society, Chicago, September, 1950.

[2] WARNER, J. C., *Chem. Eng. News*, **23**, 2584 (1950).

[3] FOWLES, G., J. CHEM. EDUC., **26**, 576 (1949); C. B. HURD, *ibid.*, **21**, 81 (1944).

nature and philosophy of research. If the problem is too difficult frustration and disillusionment may result, which may subsequently be overcome only with much effort. A "moderate" problem is the ideal, but if an error is made it should be in the direction of the simple rather than the difficult.

Originality, enthusiasm, and perseverance were considered to be more essential than facilities and equipment. Lavoisier, Faraday, and other pioneers in science were not discouraged in their efforts because they lacked a convenient source of facilities and supplies; they contrived suitable means for accomplishing their purposes. There is of course a limit of facilities below which work is not possible, but the average laboratory in a school qualified to grant an A.B. or B.S. degree is well enough equipped for a surprising amount of original work if there is the necessary will and initiative.

Many of the contributors felt that not only did the student derive benefit but that such a program was vital to the existence of the smaller institution, particularly those not giving graduate work. The reason most commonly given was that some form of research is necessary to keep up the self-respect of the instructor. If he is not able to engage in some constructive and creative enterprise, however small, he soon becomes lethargic, indifferent, or frustrated, which condition results in lowered morale and indifferent instruction. Students educated under such conditions are usually not suitably trained to compete with students coming from the more progressive institutions, and the results inevitably lead to reduced enrollment in the less progressive school. This situation was cited as one to which many college administrations should give serious consideration.

INDUSTRIAL ADVERTISING AS A SOURCE OF INFORMATION

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A FULL page ad in the recent McGraw-Hill publications states "Here's why it pays you to read the advertising. The advertising is a rich source of valuable information—leaders in business and industry turn to the advertising because they've discovered it helps them run their business more profitably—when you read all the ads in this magazine the chances are good that you'll get a lead that will materially help you do a better job."

The American Chemical Society's journal of *Industrial & Engineering Chemistry* began in September, 1950, issuing "I & EC Fact Cards" advertising in terms of physical and chemical information on 5- × 7-in. cards that could be filed for future reference. This is but another example of the solicitude that the public relations and advertising departments have for users of chemicals.

This is the third of a series in THIS JOURNAL—the previous articles were in September, 1944, and April, 1948. Here are listed more recent pamphlets and brochures dealing with various chemical problems.

We have all found there are many problems in chemistry and also in chemistry teaching that are difficult to solve or to answer—and some concerning which it is very difficult to get much information. The advertising and public relations departments have done much to give in their published works, accurate, specific information on their particular products.

For example, if you want a neat, concise summary of the history of chemistry there is nothing that even approximates the excellence of Mallinckrodt's "An Outline of the History of Chemistry." If you want some specific information on the storage battery, try "How a Storage Battery Works" and "The Storage Battery, Its Fundamentals, Use and Maintainence" by the Electric Storage Battery Company. A storehouse of facts in a pamphlet on "Ammonia" is available from Commercial Solvents Corporation. Are you interested in glycerin? The Glycerine Producers Association has available "Why Glycerine?," "Why Glycerine in Textiles?," "Why Glycerine in Drugs & Cosmetics?," "Why Glycerine in Foods?" Do you want some information on Methionine? Dow Chemical Company has an excellent pamphlet on that topic.

The following list of available information should make it easier to solve some problems as a result of specific, accurate, first-hand information from the chemical industries themselves.

INORGANIC

NH_3 Its Uses and Properties	Commercial Solvents Corp. 17 E. 42nd Street New York 17, New York
Allegheny Metal in Chemical Processing	Allegheny-Ludlum Steel Corp. Brackenridge, Pennsylvania
Graphic Baking Powder Chart (J. R. Chittick) Leavening Agents	Jaques Manufacturing Co. 111 West Jackson Blvd. Chicago 4, Illinois
The Miracle of Calcium Carbide	National Carbide Corp. Air Reduction Co. 60 East 42nd Street New York 17, New York
A Chart of Industrial Uses of Dry Ice & CO_2	Liquid Carbonic Corp. 3100 South Kedzie Avenue Chicago 23, Illinois
The History of Copper and Brass	American Brass Co. Advertising Department 25 Broadway New York 4, New York
Liquid Chlorine #7 Chlorine Bleach Solutions #14	Solvay Sales Division Allied Chemical & Dye Corp. 1 North LaSalle Street Chicago 2, Illinois
The Chlorine Handbook	Diamond Alkali Co. Cleveland 14, Ohio
The Halogen Fluorides	(*Chem. Reviews*, December, 1947) Courtesy of: Harshaw Chemical Co. 1945 East 97th Street Cleveland 6, Ohio
Liquid Glass and Solid Solutions (from J. CHEM. EDUC., 19, 239 (1942))	Philadelphia Quartz Co. 1125 Public Ledger Building Philadelphia, Pennsylvania
The Romance of Glass	Pittsburgh Plate Glass Co. 632 Duquesne Way Pittsburgh 22, Pennsylvania
Duraglas Center (Research in Glass)	Owens-Illinois Glass Co. 14th & Adams Toledo, Ohio
The Art of Making Fine Glassware	Cambridge Glass Co. Cambridge, Ohio
An Outline of the History of Chemistry	Mallinckrodt Chemical Works 20 Mallinckrodt Street St. Louis 7, Missouri
Metal Hydrides	Metal Hydrides, Inc. 12–24 Congress Street Beverly, Massachusetts
Hydrofluoric Acid Anhydrous	Harshaw Chemical Co. Cleveland 6, Ohio
Iodine	Mefford Chemical Co. 1026 Santa Fe Avenue Los Angeles 21, California
Iodine	Chilean Iodine Educational Bureau, Inc. 120 Broadway New York 5, New York
Lithium in Modern Industry (*Foote Prints*, 21, No. 2, 1950)	Foote Mineral Co. 18 West Chelten Avenue Philadelphia 44, Pennsylvania
Properties of Magnesium Products	American Magnesium Corp. 801 Gulf Building Pittsburgh 19, Pennsylvania
Nickel Alloy Steel Castings in Industry	International Nickel Co., Inc. 67 Wall Street New York 5, New York
Nuclear Physics Charts ($1.00)	Westinghouse School Service 306 4th Avenue Pittsburgh 30, Pennsylvania
Chart of Nucleides & Isotopes High Accuracy Thermocouple Wire Permanent Magnets	Educational Service General Electric Apparatus Dept. 4966 Woodland Avenue Cleveland 7, Ohio
Potassium Permanganate for Farm & Home Use	Carus Chemical Co., Inc. 1337 8th Street LaSalle, Illinois
The Story of Diamond Crystal Salt	Diamond Crystal Salt Co., Inc. St. Clair, Michigan
Salt & the Chemist	E. I. DuPont de Nemours & Co., Inc. Wilmington 98, Delaware
Silver News Letter (Monthly)	Silver Users Association 1730 Eye Street N. W. Washington, D. C.
Sodium	National Distillers Chemical Corp. 120 Broadway New York 5, New York
Curley Precision Standards of Mass, Volume, Length	Bulletin 1500 W. & L. E. Curley Troy, New York
Steel Making in America	U. S. Steel Corp. 71 Broadway New York 6, New York
Steel—From Mine to You	American Iron & Steel Institute 350 5th Avenue New York 1, New York
How A Storage Battery Works The Storage Battery, Its Fundamentals, Use and Maintenance	Electric Storage Battery Co. Allegheny Avenue & 19th Street Philadelphia 32, Pennsylvania
Edison & His Storage Battery	T. A. Edison, Inc. West Orange, New Jersey
Modern Sulfur Mining	Texas Gulf Sulfur Co. 75 East 45th Street New York, New York
Water—Your Most Important Raw Material	Hall Laboratories, Inc. Hagan Building Pittsburgh, Pennsylvania
The Zinc Industry	American Zinc Institute, Inc. 60 E. 42nd Street New York 17, New York

ORGANIC

Nealco—Industrial Alcohol	Monsanto Chemical Co. Merrimac Division Everett Station Boston, Massachusetts
The Chemistry of Fatty Amines	Armour Chemicals Division Armour & Co. 1355 West 31st Street Chicago 9, Illinois
Aromatic Industrial Solvents	Barrett Division Allied Chemical & Dye Corp. 40 Rector Street New York 6, New York

Benzoic Acid and the Benzoates	Monsanto Chemical Co. 1702 South 2nd Street St. Louis 4, Missouri
Plastics from Cellulose	General Mills Department of Public Services 400 2nd Avenue Minneapolis, Minnesota
The Story of Corn and Its Products	Corn Industries Research Foundation 3 E. 45th Street New York 17, New York
Polyethylene Glycol Esters	Kessler Chemical Co., Inc. State Road & Cottman Avenue Philadelphia 35, Pennsylvania
Esters	Glyco Products Co. 26 Court Street Brooklyn 2, New York
Explosive Products	Olin Industries, Inc. East Alton, Illinois
Why Glycerine in Drugs & Cosmetics? Why Glycerine? Why Glycerine in Foods? Why Glycerine in Textiles?	Glycerine Producers Association 295 Madison Avenue New York 17, New York
Monosodium Glutamate	Amino Products Division International Minerals & Chemicals Corp. Box 177, 20 N. Walker Chicago 6, Illinois
How to Prepare & Use Glues, Pastes & Gums	National Starch Products Co. 270 Madison Avenue New York 16, New York
Phillips 66 Hydrocarbons	Phillips Petroleum Co. Chemical Products Department Bartlesville, Oklahoma
Methionine	Dow Chemical Co. Midland, Michigan
Metallic Soaps	Metasap Chemical Co. Harrison, New Jersey
The Physical Properties of Synthetic Organic Chemical	Carbide and Carbon Chemical Corp. 30 E. 42nd Street New York 17, New York
Surface Active Agents	Atlas Powder Co. Industrial Chemicals Department Wilmington 99, Delaware
Facts About Toxaphene Toxaphene Kills Grasshoppers	Naval Stores Department Hercules Powder Co. Wilmington 99, Delaware
Current Developments by Cyanamid (Literature of various new products)	A. M. Asherman American Cyanamid Co. 30 Rockefeller Plaza New York 20, New York
Sugar as a Food	Sugar Information, Inc. 52 Wall Street New York 5, New York

MISCELLANEOUS

Testing in Modern Industry Testing Price List	U. S. Testing Co., Inc. Hoboken, New Jersey
Trends in Industrial Research & Patent Practices The Public's Stake in Patents A Seminar on What Inventions Can Mean to You	National Association of Manufacturers 14 West 49th Street New York 20, New York
A Symbol of Progress	Sinclair Research & Development Lab. Harvey, Illinois
Photographic Chemicals	Mallinckrodt Chemical Works 20 Mallinckrodt Street St. Louis 7, Missouri
A Cavalcade of Chemistry	E. I. DuPont de Nemours & Co., Inc. Wilmington 98, Delaware
Health from the Ground Up	Public Relations Department International Harvester Co. 180 Michigan Avenue Chicago 1, Illinois
Synthetic Detergents ($1.00)	J. W. McCutcheon 475 5th Avenue New York 17, New York
The Incandescent Light	T. A. Edison Foundation, Inc. Main Street at Lakeside Avenue West Orange, New Jersey
The Railroad Story	American Educational Press, Inc. 400 South Front Street Columbus 15, Ohio
50,000 Years of Protection & Decoration (History of Paint & Color)	Pittsburgh Plate Glass Co. Pittsburgh 22, Pennsylvania
Enriched Bread	American Institute of Baking Consumer Service Department 1135 Fullerton Avenue Chicago 14, Illinois
A Research Man Speaks on Chemical Problems of the Automobile	Education Service Department of Public Relations General Motors Building Detroit 2, Michigan
The Story of General Electric Research	Educational Service 1 River Road Schenectady 5, New York

A CLOCK REACTION

M. G. SURYARAMAN and ARCOT VISWANATHAN
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Two well-known, spectacular "clock reactions," for lecture demonstration are the Landolt reaction (*1, 3, 6, 7*) in which iodic and sulfurous acids interact in the presence of starch, and the Forbes' reaction (*5, 13, 9*) in which arsenious oxide in strong hydrochloric acid reacts with saturated thiosulfate. The sudden appearance of iodo-starch blue in the one case, and of a yellow colloid in the other, occur after an induction period which is lengthened by dilution of the reactants in conformity with the Mass Action law. Also, the induction period for the Landolt reaction is lengthened by addition of ethyl alcohol (*2*) and other inhibitors, and by increase in pH (*10*).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Iron solution, ml.	30	50	70	50	50	50	50	50	50	50	50	50
Water added to iron solution, ml.	40	20	0	30	50	70	20	10	0	50	70	50
NaI retardant, ml.	...	...	...	...	...	...	0	10	20	...	...	...
C_2H_5OH accelerator, ml.	...	...	...	...	...	...	...	...	...	0	0	20
Iodine solution, ml.	1	1	1	1	1	1	1	1	1	1	1	1
Decolorization time, sec.	35	24	19	28	17	14	32	61	92	18	14	7

A third clock reaction is as follows. Ferrous ions in an alkaline solution of a tartrate form a soluble chelate complex (compare copper in Fehling's solution (*4*)), which reacts sluggishly with iodine:

$$I_2 + H_2O + 2Fe\ (II)\ \text{tartrate complex} \rightarrow 2Fe\ (III)\ \text{tartrate complex} + 2HI$$

MATERIALS

Water. Since the chelate complex is oxidized by air (*8*), distilled water used in the experiment must be boiled free of dissolved air; also, the solutions must be stored in well-stoppered bottles.

Iron Solution. Dilute to 1 liter a mixture of 3.77 g. of Rochelle salt ($KNaC_4H_4O_6.4H_2O$), 4.48 g. of sodium bicarbonate, 33.3 ml. of ferrous sulfate solution (55.6 g. $FeSO_4.7H_2O$ per liter of solution), and 47 ml. of a 1 per cent solution of starch.

Iodine Solution. 12.7 g. of iodine plus 25 g. of sodium iodide in a liter of water.

Sodium Iodide Solution. 15 g. in a liter of solution.

Ethyl Alcohol. 95 per cent solution.

EXPERIMENTAL

The table shows the volumes of the above solutions which were mixed simultaneously at 29 to 32° C., and the times required for the blue color to disappear.

In experiments 1 to 3 the concentration of iodine is held constant, and the induction period shortens with increasing concentration of the ferrous complex; this is the same mass law behavior as in the Landolt and Forbes reactions. However, experiments 4 to 6 show that if the concentrations of both iodine and the ferrous complex are simultaneously increased, the induction period lengthens (the reaction rate decreases); apparently upon increasing the concentrations the accelerating action of the ferrous complex is less favored than is the retarding action of NaI_3 and I^- (the solution forms NaI_3 from $NaI + I_2$).

Experiments 7 to 9 show that NaI retards reaction, lengthening the induction period. Experiments 11 and 12 show that ethyl alcohol accelerates reaction, shortening the induction period, while 10 and 11 are identical to 5 and 6.

Separate experiments showed that with pure iodine in alcohol, NaI being excluded, decolorization was practically instantaneous even though a little iodide is formed as one of the products. Retarding action of other halides showed NaI > NaBr > NaCl > NaF, being least with NaF. Sodium citrate, substituted for Rochelle salt, gave slightly faster reactions but the same relative orders.

On the basis of the experiments above, it is suggested that in the method of Rupp (*11*) and of Tananaev (*12*) for iodometric estimation of ferrous salts by the use of this ferro tartrate complex, the time for titration can be considerably shortened by adding some ethyl alcohol to the reactants.

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KEEPING PROPERTIES OF CERTAIN VOLUMETRIC SOLUTIONS

BARBEE WILLIAM DURHAM
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Storage Time and Stability of Various Standard Solutions

Solution	*Date of preparation*	*Standardized against*	*Factor*	*Date of restandarization*	*Factor*	*Change*	*Time elapsed, months*
Calcium chloride	6/29/44	Silver nitrate	0.0751	10/30/45	0.07512	0.0000	16
Ferrous ammonium sulfate	3/3/47	Iodine and sodium thiosulfate	0.1017	6/28/50	0.0905	0.0112	39
Iodine[a]	1/12/48	Sodium thiosulfate	0.05030	6/28/50	0.04947	0.0008	30
Potassium ferrocyanide[b]	6/23/49	Zinc	0.0520	12/15/50	0.0513	0.0007	18
Potassium permanganate[c]	10/15/47	Sodium oxalate	0.01986	2/3/48	0.01960	0.00026	13
Potassium permanganate	5/25/43	Sodium oxalate	0.10242	9/26/44	0.10250	0.0000	16
Sodium hydroxide[d]	9/10/49	Potassium acid phthalate	0.00997	2/27/50	0.00988	0.0001	5
Sodium hydroxide	4/9/48	Potassium acid phthalate	0.02510	12/27/48	0.02490	0.0002	8
Sodium hydroxide	9/22/43	Potassium acid phthalate	0.25025	3/29/44	0.25028	0.0000	6
Sodium meta Periodate	9/4/47	Sodium thiosulfate	0.2492	2/16/49	0.2491	0.0001	17
Oxalic acid	9/19/46	Sodium hydroxide	0.1007	7/7/50	0.0995	0.0012	46
Sodium thiosulfate[b]	1/10/45	Potassium iodate	0.01328	11/4/46	0.01326	0.00002	22
Sodium thiosulfate[b]	1/28/48	Potassium iodate	0.02040	3/3/50	0.01990	0.0005	26
Sodium thiosulfate[b]	2/12/46	Potassium iodate	0.10015	8/7/46	0.10015	0.0000	6

[a] One of the factors which affects iodine is increased temperatures during summer months. This is particularly true if the bottles are not extremely well stoppered.
[b] These solutions contain 0.02% sodium carbonate as a preservative.
[c] The potassium permanganate solutions were prepared from a stock solution which had been boiled, allowed to stand, and then filtered through asbestos fiber.
[d] The sodium hydroxide solutions were prepared from carbonate-free saturated solutions, and stored in pyrex bottles.

THE keeping properties of volumetric solutions is of interest to research workers in several fields of endeavor, especially that of chemistry. Although most analysts are familiar with the properties of solutions within their particular sphere of interest, specific information is frequently needed about an unfamiliar solution or for the occasional user of ordinary standard solutions.

The Control & Reagent Laboratory of Ohio State University prepares reagents for the several departments of instruction and for campus research projects and specializes in volumetric solutions. Frequent inquiries from research workers concerning the stability of various solutions have prompted the keeping of restandardization records.

The above compilation is from these records and each entry is a sample of the information collected over a period of eight years. The primary purpose of the restandardizations was to discover significant changes in the normality factor, where there was a question as to stability, rather than to do research on the keeping properties of these solutions.

The chemicals used in the preparation of these solutions were, unless otherwise indicated, of the usual c. p. reagent quality and the water, distilled by means of a Barnstead still, was of high purity. Its pH was between 6.0 and 6.5 and the specific resistance was greater than 377,400 ohms.

Restandardizations were, in most instances, carried out against a different lot of the same primary standard as was first used in determining the factor and the same indicator was used.

Though there is much in the literature concerning the stability of volumetric solutions, these data will be of interest to many research workers because they tend to indicate that solutions of iodine, sodium hydroxide, potassium permanganate, and sodium thiosulfate, when properly prepared and stored, keep longer than the literature states in some instances.

ATOMIC STRUCTURE MODELS FOR CLAY MINERALS

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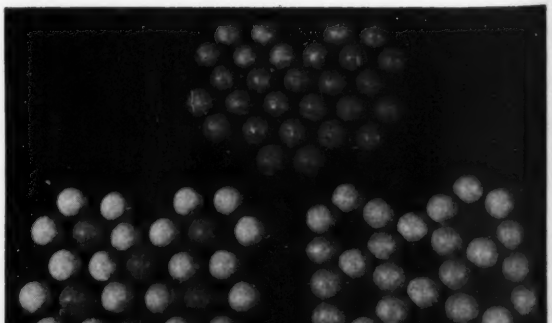
THERE are several different sets of commercial models available to demonstrate the atomic structure of chemical compounds. These sets in general are excellent for certain purposes but they all lack desirable features for illustrating the space-lattice configuration of the clay minerals and are somewhat expensive. The following described atomic structure models of clay minerals use cheap materials, involve a minimum of cash outlay, and may easily be made to demonstrate the space-lattice structure of minerals in accord with the scientist's desires. With reasonable care and patience the models may be made to meet desired dimensions with a high degree of accuracy, and it is not difficult to make a very refined model.

Aluminum and Magnesium, Oxygen, Hydroxal, Octahedrons

The structure of clay minerals has been studied by Pauling (*1*), Bragg (*2*), Marshall (*3*), Grim (*4*), Hendricks (*5*), and many others and they have used wood balls, rubber balls, glass marbles, plastic materials, and paper forms to demonstrate and study the crystal lattice of the clay minerals. Excellent models have been made but in most cases the cash cost of such models has been an undesirable factor.

The models described herein may be made with any good ceramic clay that may be dug in many localities or purchased from commercial concerns,[1] steel wire of about 10 gage, water colors, clear lacquer, and a muffle furnace. The clay should be well wetted and allowed to stand overnight and then allowed to dry to such a moisture content that the individual atom replicas will hold their shape without slumping while drying. The size of the individual atoms may be determined by reference to Pauling (*1*) or Marshall (*3*) or other authors, and a convenient ratio to use in constructing the atoms is 2.5 cm. per Angström unit. The amount of clay required to construct each atomic species to size may be determined by trial and error and the amount of clay replicated by weight or measured volume. The lumps of clay may be rolled into almost perfect spheres by rolling them between the palms of the hands. If sufficiently dry clay is used to prevent slumping on drying, a crack may appear in the surface of the sphere. Such cracks may be eliminated by rubbing them with a wet finger. The balls or atomic replicas may be held in desired positions, such as the hexagon rings characteristic of the clay minerals, by steel wires. The maintenance of the position of the balls while constructing the space lattice configuration may be effected by the use of a piece of wood or similar material with holes drilled in the proper positions. The individual groups of atom replicas should be thoroughly air dried, then dried in the 100°C. oven, and then fired in a furnace at about 650° so as to set the clay.

After cooling, the individual atoms may be painted with water colors followed by a coat of clear lacquer, and a stable model will result. If desired a much higher temperature may be used for firing so that the clay will vitrify, making china or porcelain models.



Oxygen, Oxygen Hydroxal, and Hydroxal Layers of Clays

[1] The Art Clay Co., Indianapolis, Indiana, or local school supply store.

but it does not seem that the resultant models would be sufficiently improved to warrant the extra work. Any good book on pottery or china manufacture, such as Jenkins (*6*), would contain many helpful hints to the scientist who wishes to construct models of atomic structure.

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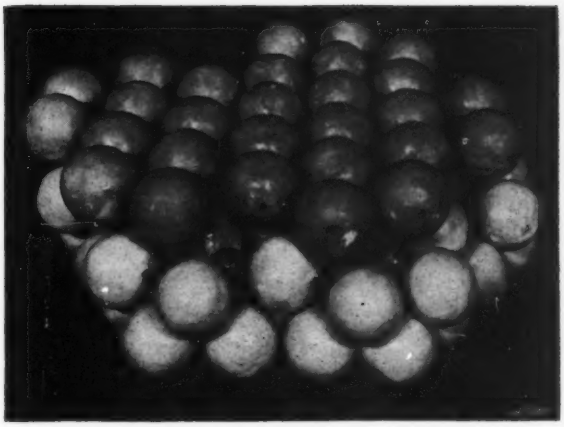

Kaolin Showing Silicon, Aluminum, Oxygen, and Hydroxal Units

AN ION-EXCHANGE EXPERIMENT FOR QUANTITATIVE ANALYSIS

WILLIAM M. MacNEVIN, MARY G. RILEY, and THOMAS R. SWEET
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THIS experiment demonstrates how ion-exchange resins may be used to simplify the process of inorganic analysis. A sample containing inorganic sulfates, such as a mixture of ferrous sulfate and ammonium sulfate, is passed through a column of resin of the cation-exchange type. The cations of the sample exchange with hydrogen ions of the resin producing a dilute solution of sulfuric acid which is drawn off at the bottom of the column. The acid is then titrated with standard sodium hydroxide and the percentage of SO_3 calculated from the results. It is assumed that all of the SO_3 is in combination with a positive ion, as in ferrous sulfate or ammonium sulfate, and that no other anions are present.

Ion-exchange resins consist of complex organic molecules, usually insoluble, which possess ionizable atoms or groups. Those possessing replaceable cations such as sodium or hydrogen ion are called cation-exchange resins. An example of a cation-exchange resin is called "Dowex 50."[1] It is a sulfonated aromatic hydrocarbon polymer which contains many $-\overset{|}{\underset{|}{C}}-SO_3^-$ groups on the surface. These groups attract positive ions. For example, after such a resin had been treated with hydrochloric acid, the group would be present as $-\overset{|}{\underset{|}{C}}-SO_3H$. If it is then exposed to a solution containing a metal ion, the following exchange reaction occurs.

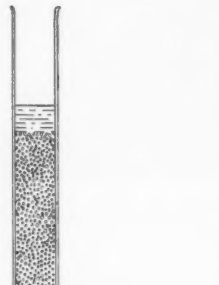
$$-\overset{|}{\underset{|}{C}}-SO_3H + M^+ \rightarrow -\overset{|}{\underset{|}{C}}-SO_3M + H^+$$

The process of exchange is a rapid one and it goes to completion so that it is useful analytically.

Exchange resins are used in a vertical tube or column, as shown in the figure. A porous plug at the bottom of the column retains the resin but allows the solution to pass through. The resins are prepared as small spheres or granules (Dowex 50 is 20 to 60 mesh) which pack well but do not prevent the flow of solution. The size of column and amount of resin needed depend upon the quantity of material to be treated and upon the

[1] Obtainable from the Dow Chemical Co., Midland, Michigan. Also sold as "Ion X" by Microchemical Specialty Co., 1834 University Ave., Berkeley 3, California.

capacity of the resin. "Dowex 50" is rated as having a capacity of 5.1 milliequivalents per gram of resin. One gram of the resin, when exchange is complete, should liberate acid equivalent to 51 ml. of 0.1 *N* acid. Of course, the efficiency of the exchange process decreases as the exchange reaction progresses and a considerably larger quantity of resin is necessary in order to make the process quantitative. The efficiency of exchange is also less the more rapid the flow of solution through the column. With a column of resin 15 cm. in length by 15 mm. in diameter, a rate of flow of 15 ml. of solution per minute will give efficient exchange for three or four runs in which 5.0 milliequivalent quantities are used in each run.



Ion-Exchange Column

Exchange resins often undergo changes in volume either upon wetting the dry resin or during the exchange process. For example, if acid is poured into a dry column of the sodium form of "Dowex 50" expansion will occur and columns have been known to explode dangerously as a result of the expansion pressure. This can be avoided by wetting the resin before the column is filled and secondly by packing the column while the resin is in its expanded hydrogen form. The swelling of the resin on wetting also causes a pronounced change in its density. With "Dowex 50", for example, the density decreases from 1.55 for the dry resin to 1.41 for the wet resin.

Cation-exchange resins eventually become saturated with metal ions and must be regenerated or converted back to the hydrogen form. To do this a quantity of 10 per cent hydrochloric acid is poured through the column, and then washed out with distilled water.

Preparation of Resin. Place about 8 g. of "Dowex 50" cation-exchange resin in a beaker, cover with water, and let it stand at least one hour, preferably overnight. Mount the column and place a small wad of glass wool on top of the perforated plate at the base of the column. Pour the slurry of resin and water into the column. Do not allow the water level to drop below[2] the top of the resin at any time. If air bubbles are trapped in the resin, shake the column until they are disengaged. The column should now be about half full.

[2] Channeling will occur on refilling the column if the water level is allowed to drop below the top surface of the resin.

Prepare and pour through the column 400 ml. of 1:10 hydrochloric acid at a rate of about 15 ml. per minute. Wash out the excess acid with distilled water until the pH of the wash water is greater than 5 as indicated by methyl red. This will require approximately 500 ml. of wash water. The column is now ready for use.

Procedure. Weigh about 0.25-g. samples containing metal sulfates (ferrous ammonium sulfate, ammonium sulfate mixtures) into dry 400-ml. beakers. Dissolve the first sample in 15 to 20 ml. of distilled water and pour the solution quantitatively into the column. Rinse the beaker once with 10 ml. of distilled water. Open the stopcock at the bottom of the column until the rate of flow is about 15 ml. per minute. Collect the eluted solution in a 400-ml. beaker. Rinse the beaker several times more with distilled water and continue to wash the column with distilled water until a drop of eluate placed on a pH test paper[3] shows a pH value of not less than 5. Approximately 150 ml. of wash water will be needed. Cover the beaker containing the eluate and set it aside. Treat the second and third samples in a similar way.

Titrate each of the acid solutions with 0.1 *N* standard sodium hydroxide using phenolphthalein as indicator. Calculate the percentage of SO_3 in the sample assuming that sulfate was the only anion present.

Results. This method has been applied to mixtures of metal sulfates similar to those[4] given out as samples for analysis in undergraduate courses in quantitative analysis. After the method was developed and thoroughly tried by the authors, it was tested by Miss Barbara Grosjean, at that time a senior student at The Ohio State University. Sample data are given in the table.

Determination of Sulfate

Sample, g.	*Base,*[a] *ml.*	% SO_3 *Theory*	% SO_3 *Found*
0.2502	28.03	50.15	50.23
0.2386	26.62		50.02
0.2362	26.34		50.00
0.2562	26.84	47.02	46.97
0.2493	26.10		46.95
0.2774	29.26		47.29
0.2773	32.87	53.12	53.15
0.2461	29.12		53.05
0.2713	32.12		53.09

[a] 0.1120 *N*.

The conclusion is reached that the method is sufficiently reliable and reproducible to justify its use by students as an illustration of ion-exchange resins in quantitative analysis. The experimental work is relatively simple. The preparation of the resin and the necessary precautions emphasize the important chemistry of ion-exchange resins.

[3] Hydrion pH papers are available at most scientific supply houses.

[4] Ferrous ammonium sulfate samples are supplied by Thom Smith, 1847 North Main St., Royal Oak, Michigan.

Proceedings of the

PACIFIC SOUTHWEST ASSOCIATION OF CHEMISTRY TEACHERS

ANALYTICAL CHEMISTRY—HOW IT SHOULD BE TAUGHT[1]

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On my office wall hangs a picture showing two men in knee britches. They are working with a telescope with a large wheel mounted on a table on which rests a prism. An explanation under the picture reads: "Joseph Fraunhofer 1787–1826, Inventor of the Spectroscope, Was the First to Measure and Designate the Dark Lines of the Solar Spectrum." 1800 is 150 years ago. Yet absorption spectra have reached analytical chemistry only within the past few years. Why was this principle not applied sooner? It would seem that either Fraunhofer and his followers did not know enough analytical chemistry or the analytical chemists did not know enough physics.

This points to one thing that needs careful consideration: how much specialization is desirable in teaching analytical chemistry? On the one hand, in large universities there is a strong tendency to specialize very highly in the graduate years. This is carried down to some extent into the undergraduate program. On the other hand, in the small college there is the opposite tendency. The professor has a larger variety of classes and usually less research time.

Another factor to consider is the student. Chemistry (and chemical engineering) majors fall into groups, according to the fields for which they are preparing: (1) those preparing for research positions after four years of training, (2) those planning to teach chemistry and related subjects in secondary schools, and (3) those planning graduate work for an advanced degree.

A chemistry major may desire at any time during his training to concentrate on analytical, inorganic, organic, physical, biochemistry, or some even more specialized field, and should be appropriately advised.

Aside from chemistry majors, we have another group that requires analytical chemistry. It is made up of premedical, predental, prepharmacy, laboratory technician, geology, engineering, biology, etc., students.

Although this discussion will center upon training analytical chemists for industry, we must keep in mind training for other types of chemical work and determine how these fit into the over-all program of education.

An analytical chemist going into an industrial organization or research group should, I think (1) have suitable personality—be adaptable, agreeable, honest, enthusiastic, etc., (2) have ability to express himself clearly and concisely, both orally and in writing, (3) be well grounded in basic principles of chemistry and related fields, especially analytical chemistry, (4) be trained in manipulative skills, and (5) have the ability to do original thinking and to make sensible interpretations of data.

These qualifications in the trainee would also be very desirable in applicants for other positions open to the graduate. For the prospective teacher additional training and practice in methods of presentation and dealing with younger people should be included.

The analytical chemistry teacher can help obtain such people in several ways. One very effective way is by precept and example. Another is by support of and participation in a careful screening program for students entering college and choosing a major.

For example the time worn "liquidation" method of failing 40 per cent of the students in each semester of freshman chemistry and 40 to 60 per cent in the first semester of sophomore chemistry is antiquated and unfair as a method for selecting desirable trainees. It also creates bad public relations. Admission requirements, testing, advising, and guidance into appropriate fields are much more effective. Such a program is being developed at Fresno State College. Of course, there will always be screening by achievement standards set in courses.

I know of no better place to teach the virtues of honesty than in quantitative analysis. The nature of the subject leads to honest endeavor in practice and in theory.

There is a tendency among chemistry majors to belittle such subjects as English and social sciences. Some of the questions on written chemistry examinations can be given in such a way that the student must begin with a capital letter and end with a period in giving a definition, describing a method, or explaining a theory. Mistakes in English should be marked. Such words as *clearly, concisely, briefly,* and *fully* should appear frequently in examination questions. There is

[1] Presented in a panel discussion at the October 21, 1950, meeting of the Association.

no more eloquent declaration of ignorance than the inability of a college graduate to speak and write his native language well. Every chemistry major should fully realize this as soon as possible.

What subject matter should be included in analytical chemistry? We should not lose sight of the traditional qualitative and quantitative, volumetric and gravimetric chemistry. Volumetric and gravimetric analysis help many students, for the first time, really to understand what chemistry is all about.

In addition to these and a few other methods used in organic chemistry we now recognize the importance of the following general procedures:

Spot testing
Electroplating
Refractometry
Potentiometry
Viscosimetry
Microscopy and crystal structure
Polarimetry
Colorimetry, nephelometry, fluorescence, reflectance, and color (visual or photoelectric, using infrared, visible, and ultraviolet)
Spectrophotometry (including emission, absorption, fluorescence, and reflectance; in the ultraviolet, visible, infrared, and microwave)
Conductometry
Interfacial tension
Polarography
Gas analysis
Ion exchange
Radioactive tracer techniques
Microanalysis
X-ray diffraction
Raman analysis
Electron microscopy
Mass spectrometry

There are doubtless additional methods of analysis being developed. Automatic recorders are commercially available for several of the methods listed and automatic process controls based upon them are in use in some of the chemical industries.

Several years ago, when I mentioned the lack of training in the theory and use of these methods in chemistry to Dr. McBain, Stanford's well-known colloid chemist, his comment was, "We *must* make them available." This doubtless also expressed the view of many leaders in other branches of science. I believe instruments for all but the last three or four methods listed can now be made available in most colleges that train chemists.

Specific responsibility for each instrument should be placed upon a regular staff member. Other staff members, and their students who are specifically assigned, should be allowed to use them. Instrumental analysis will then enlarge and improve the entire program.

A suggested program in analytical chemistry follows, for a college granting the A.B., B.S., and master's degrees. This is based upon the experience at Fresno State College.

Freshman Year

Common cation qualitative analysis (semimicro); equations, theory, and problems stressed.

Sophomore Year

Theory and problems stressed. Precision is required in the laboratory. Normax glassware, class S weights (one set per student), and chainomatic balances with magnetic dampers are used. Burets, pipets, and weights are calibrated by major students.

I.[2] Volumetric analysis and one or two instruments.

I. Volumetric and gravimetric analysis and one or two instruments for nonchemistry majors.

II. Gravimetric analysis and anion and rarer element qualitative analysis (macro).

Some experience with ores, alloys, and substances difficult to dissolve is obtained, including some of the rarer elements.

Junior Year

I. Qualitative organic analysis, required for B.S., optional for A.B. degree. (Taught by an organic chemistry professor.)

Senior Year

II. Instrumental analysis, required for B.S., optional for A.B. degree. Prerequisites: two semesters quantitative, two semesters organic and physical chemistry (latter may be taken concurrently).

I or II. Analytical laboratory research project, honors course for the better students. (Written and oral reports required.)

Graduate Year

II. Advanced quantitative analysis—theory, reading of the literature, reports, may include laboratory work.

I or II. Thesis in analytical chemistry; analytical laboratory research project; seminar topics.

This program is adequate to supply the needs of each type of student. It is broad enough to permit some specialization in analytical chemistry by students planning careers in industrial work or in teaching, especially at the junior-college level where analytical chemistry is a commonly offered subject.

According to recent articles, students beginning graduate work at Purdue University[3] and other universities are especially weak in inorganic chemistry. A frequently quoted comment by Dr. Reedy, I believe, of the University of Illinois, is, "There is no better place to teach inorganic chemistry than in qualitative analysis." The inclusion of anions and rarer elements in the last half of the sophomore year gives the student additional training in inorganic chemistry. It also gives him a feeling of familiarity with the rarer elements that are persistently becoming less rare, because of industrial applications. This type of experience also makes the graduate feel less helpless when confronted by a student or a colleague who wants to know the composition of some naturally occuring substance.

There are several other recent plans for a reorganized analytical chemistry curriculum now in use. For example at Brown University[4] much of the conventional undergraduate quantitative as well as instrumental analysis is concentrated in one course offered in the senior year; and at Massachusetts Institute of Tech-

[2] I and II indicate first and second semesters.

[3] BROWN, H. C., AND C. L. RULFS, J. CHEM. EDUC., **27**, 437–40 (1950).

[4] COLES, J. S., L. B. CLAPP, AND R. P. EPPLE, J. CHEM. EDUC., **26**, 10–14 (1949).

nology there is a much larger program leading to a Ph.D. degree in instrumental analysis. The recently described specific laboratory experiments required in the instrumental analysis course at Union College[5] seem quite satisfactory for this course as offered by colleges. They can be varied from year to year.

[5] EWING, G. W., J. CHEM. EDUC., 27, 297–8 (1950).

To return to the original question of how much specialization is desirable, I think a broad background in English and liberal arts and a little biology are essential. At least mathematics through calculus and two years of physics should be required for a B.S. degree. In most instances even the graduate student should be strongly advised to take considerable course work in fields outside of, but related to, chemistry.

THE USE OF A DRILL PRESS FOR BORING HOLES IN STOPPERS

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Crossett Lumber Company, Crossett, Arkansas

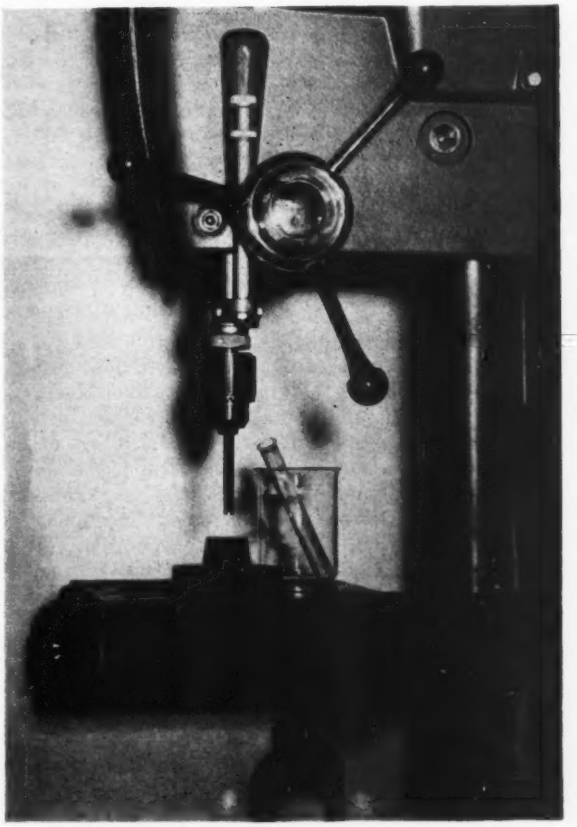
MANY laboratories may find it to their advantage to use a drill press for boring holes in cork or rubber stoppers. With little effort, holes can be bored more accurately and more rapidly than by using the conventional cork borer. Moreover, the drill press may be readily adapted for this purpose.

To do this, select a set of hand cork borers, and with a hacksaw cut off the handles by sawing through the tube near the upper end. The borer, without the handle, can now be used like a drill and chucked in a Jacobs chuck on a drill press as shown in the illustration. The chuck should be tightened by hand with only moderate pressure. If closed too tightly the jaws of the chuck will deform the borer. Most drill presses are equipped with a $^1/_2$-in. Jacobs chuck which limits the maximum size of the borer to a No. 9. However, larger chucks can be obtained.

The drill press should be operated at speeds below 400 r. p. m., and preferably about 200 r. p. m. Lubrication is provided by dipping the borer in a test tube containing a solution of Dreft or similar detergent before boring each hole. With proper lubrication, three or four holes can be bored without removing the cuttings from the tube. When the tube is filled with cuttings they can be ejected easily by removing the borer from the chuck and forcing them out with a metal rod.

By this means, holes can be bored accurately to specifications. With rubber stoppers, adjacent holes can be bored with less than $^1/_{32}$-in. clearance on either side. Also, relatively large holes can be bored in small stoppers. Oblique holes may be bored by using wedges to support the stoppers or by tilting the drill press table.

Many laboratories have drill presses available that could be used for this purpose. However, the initial cost of a press is not unreasonable when it is considered that the tool is suitable for many other uses. Actually, the less expensive presses are in the same price range as the usual type of laboratory cork boring machines.



Use of a Drill Press for Boring Holes in Stoppers

Report of the

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

A SERVICE TO INDUSTRY[1]

JOHN B. CALKIN
University of Maine, Orono, Maine

THE dependence of economic welfare and progress upon industrial research is evident, and industrial development is dependent upon fundamental and applied research. Research is a necessary part of our business fabric and national economy.

The growth in both number and size of industrial research units in our academic institutions is indicative of a growing use of organized academic facilities for industrial research. In fact, the growth has been sufficiently marked to elicit criticism from some private laboratories, and yet other private laboratories have endorsed the place of universities in this type of research.

The entrance of colleges and universities into the field of industrial research is not new. Much of the early work in the chemical industry, particularly in Germany before World War I, was done by university professors in their laboratories. The fees received by the German professors were quite liberal in those early days.

However, in recent years a new concept has entered the picture. This is that research work of this type should be done under the auspices of, or sponsored by, the institutions themselves, with staff members of the institution, or a special staff, performing the work. With the multiplicity of problems and research skills required, the university staff has much to recommend it for putting a research task force or team onto a project.

Thus we plan to discuss an administrative program as it impinges on industry and on the university. Specifically, we are going to examine some of the features of administration and operation of the Department of Industrial Cooperation, or as we call it, the DIC, at the University of Maine.

A SERVICE TO INDUSTRY

Research investigations may fall into three categories:

1. Fundamental research—investigation for the advancement of knowledge by finding new truths.
2. Applied research—investigation for the application of knowledge to wholly new problems that may develop new industries, new products, new processes, or new methods for management.
3. Technical development—investigation for the improvement of present products, processes, and management methods.

Fundamental research is a primary function of the universities and in conducting this research they have contributed greatly to our national well-being. The importance of fundamental research as the forerunner of applied research cannot be overemphasized. Applied research and technical development are primarily the responsibility of industry; and it is evident that all industry, large, medium, or small, should have available the means for conducting investigative studies. One of the methods of providing this means is the use of university facilities.

We at the University, and our Industrial Advisory Council, composed of prominent people from industry in the State of Maine, recognize the value of a program which brings industry and the University into close cooperation. Maine industry, with its preponderance of small organizations, can benefit particularly from cooperative university studies. Small companies cannot usually afford to maintain their own research departments, yet their need for investigations may be great. At the same time, larger companies that maintain research departments can benefit by promoting the fundamental research which makes their applied research possible and by augmenting their own research in problems where additional specialized personnel and special facilities are advisable.

OBJECTIVES

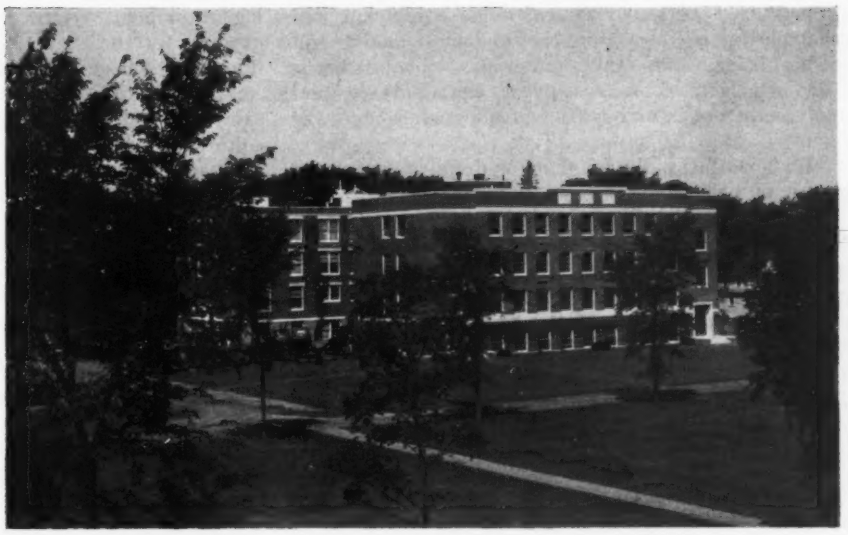
The objective of the Department of Industrial Cooperation is to place the personnel and equipment of the University of Maine at the disposal of industry to the extent consistent with the functions and policies of the University.

Both small and large industries participate in this

[1] Presented at the Twelfth Summer Conference of the New England Association of Chemistry Teachers, University of Connecticut, Storrs, Connecticut, August 22, 1950.

plan to the degree dictated by their own professional facilities and needs. Small units with limited professional personnel use the facilities of the Department of Industrial Cooperation to a great extent, whereas for larger companies the facilities of DIC augment the research performed by these companies and also fill existing professional gaps. Investigations and consultations for groups or associations are also prosecuted through the DIC.

The department fosters industrial cooperation by serving as a general clearing house for the University on all industrial matters. It is a focal point in the University organization which industry may contact to obtain the best qualified person or persons at the University to be consulted on a certain problem whether small or large. This department is industry's liaison with the University.



Aubert Hall (Chemistry and Chemical Engineering Building), University of Maine

COOPERATIVE INVESTIGATIONS

There are, of course, many problems which can be solved only by thorough investigative work—by research and engineering. The DIC welcomes the opportunity to discuss these cases, and, if it appears feasible, to make proposals for contractual arrangements whereby these problems will be investigated at the University.

The field of application for cooperative studies of this nature is wide. Through this medium service is rendered to any industry, large or small, or to any industrial group or association. The type of investigation varies over an equally wide range—from the short-term, practical problem in process development and improvement to the more involved long-range problem leading ultimately to improvements in existing industries or the development of new industries. Such studies are carried out, on the one hand, for large industries, groups, or associations which have their own research facilities but sometimes require specialized personnel and special facilities which the University can furnish; and on the other hand, for small industries which do not have research facilities.

SCOPE OF THE SERVICE

By utilizing the academic departments and experiment stations of the University, the DIC has available specialized personnel and special facilities in the fields of the basic sciences, the various branches of engineering, and the economic and social sciences. These departments have undertaken many industrial studies in the past, studies which in breadth and variety embrace practically all fields of industry, and vary from laboratory research to plant-scale tests.

The University has been active for many years in highway research and in the testing of highway materials. In this field an official testing and research laboratory has been maintained for the State Highway Commission since 1914. Service of this nature has been and will continue to be available to industry.

The Maine Agricultural Experiment Station was established in 1885 to provide service and research facilities for agriculture. The services of this laboratory are available to industrial concerns through the DIC. Food studies for industrial concerns are being prosecuted currently.

Many significant studies have been carried out for the wood-using industries. The handling and processing of lumber, plywood manufacturing and testing, chemical pulping, the development of specialty papers, and the extraction of oils from native conifers are recent subjects of investigation.

The University is particularly well equipped to handle problems in food processing. By combining the facilities of the Colleges of Agriculture, Arts and Sciences, and Technology, all phases of such problems may be considered. Although considerable progress has been made in this field, the possibilities in food dehydration, canning, freezing, production of extracts, and the like are still relatively untouched and are most attractive. One recent cooperative investigation was concerned with the application of unique methods to fish processing and proved to be of particular industrial importance.

Work has been initiated recently to assist the State of Maine Insurance Commissioner to reduce the hazards and losses by fires. This work is an example of excellent cooperation between various University and State departments.

Specialized personnel and special equipment are available for chemical and bacteriological analyses of foods, drugs, and other materials. The same is true of chemical microscopical examinations and analyses of paper and textile fibers, metals, and the like.

Fundamental studies involving hydraulics, equipment design, and electronics are in progress.

The field of cooperative studies should by no means be confined to purely technical problems. Research along other avenues, as for example, on such economic problems as marketing surveys, consumer income studies, accounting procedures, and the like, would in many instances be equally as productive as technical research. Consideration of plant safety problems, policies, and practices is another field in which a real contribution can be made.

TYPES OF WORK

In general, the work performed under the DIC auspices may be divided into three groups, which are as follows:

(1) *Industrial research fellowships.* This is a field of activity to be recommended particularly to the larger industries, and to industry groups and associations. It has the dual benefit of providing a means for the accomplishment of research, and contributing to the education of deserving students who need financial assistance.

(2) *Industrial research projects sponsored by a particular company, group, or association.* To fulfill the objective of providing research staff and facilities to industrial organizations, specific problems of individual companies will be investigated, provided, of course, they contribute to the general public betterment. Such studies are best handled as cooperative projects and hence represent a major contribution to industry. They cannot, however, be financed legitimately from University funds, and outside support is therefore necessary.

Such specific investigations are undertaken according to an agreement between the University and a sponsor, under which the sponsor finances the study. The investigation is conducted on a confidential basis with periodic reports to the sponsor. The sponsor reimburses the University for the cost of the work, which includes salaries, supplies, utilities, and reasonable allowances for equipment depreciation, administrative overhead, and the like.

(3) *Miscellaneous small jobs.* These jobs vary widely in character, and have included testing of heating equipment, electrical equipment, and fire-extinguishers for the State Insurance Department; determination of heat value of starch samples and of coal samples; analysis of ore samples, and of bearing metal samples; paper fiber identifications; engineering consultations; study of new paper coating material; evaluation of electronic kiln; study of air pollution in paper mill; fertilizer analyses; analyses of granite cleaning compound; analyses of crusher dust; and other investigations.

With the exception of the general information service, all the work that the DIC does carries a charge and all persons doing work receive compensation. The DIC relies wholly on the academic departments and the experiment stations to perform the work required. In this they have a free choice of whether or not they wish to do the work.

The academic departments and the experiment stations are thus in effect the operating departments under the auspices of the DIC. Work is carried out by staff members, graduate students, or undergraduates, depending upon the nature of the work. At times the DIC may guarantee for a specific period the whole or part of the time of a staff member for this type of work, but no one is required to undertake such an agreement.

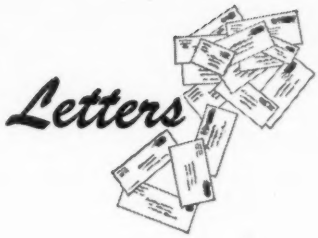
PATENTS AND PUBLICATIONS

The patent policy of the University, adopted in 1942, is given in "Survey of University Patent Policies" (page 148), published by the National Research Council (1948), along with the patent policies of thirty-odd other institutions.

Industrial research fellowships are based on a *pro bono publico* policy. The publication of results from sponsored projects is by contract or mutual agreement between the sponsor and the University. By and with the consent of the sponsor, graduate students may use the DIC work as a thesis project toward the master's degree. Naturally, the initiative in this respect would be taken by the academic department concerned.

ACKNOWLEDGMENT

The DIC has a Technical Advisory Committee composed of members of the Faculty, and also an Industrial Advisory Council composed of representatives of Maine industry. These two groups, together with the administration, have been most helpful in this work and their assistance and cooperation is gratefully acknowledged.



To the Editor:

In the paper, "The role of the liberal arts college in the professional training of chemists," by Harry F. Lewis, which appeared in the February issue of the JOURNAL OF CHEMICAL EDUCATION, the author implied that those colleges whose names did not appear in the table, "Ratings of Colleges as Baccalaureate Sources of Chemistry Doctorates," were "seemingly more interested in the morals or pleasures of the student than in the development of his intellectual resources." While one can agree wholeheartedly with the author's censure of those colleges which place primary emphasis on the pleasures of the students; disagreement must be registered with his implied condemnation of those colleges which are more interested in the morals of their students than they are in encouraging them to obtain a doctorate in chemistry.

In view of events, it would seem that public office is no longer considered by many as a sacred trust, but as a vehicle of self-enrichment. The recent disclosures of the Kefauver and Fullbright Committees need no further amplification or delineation. The spectacle of Congressmen and other government officials receiving jail sentences for financial irregularities in connection with the conduct of their offices; the sordid picture of the "five-percenters" and the "deep-freezers"; the graft and corruption in the various departments of our municipal governments; the file of some 700 letters written by Senators and Congressmen to influence the decisions of the R.F.C.; all indicate that public morality is on a very low level; and public morality is only a reflection of private morality. We have become so inured to graft, corruption, and the peddling of influence in public office that it is almost impossible to arouse the citizenry when they are revealed. However, when a Senator of the United States deems it necessary to propose an inquiry into the moral level of the Executive Branch of the federal government, this surely must give us pause.

In view of the well-known and widespread immorality or amorality of public and private life in our country, can we assume that our institutions of higher education are doing all that can be rightfully expected of them? Of what avail is it to train excellent scientists, lawyers, doctors, dentists, business men, etc. if they are not simultaneously trained to use their talents and knowledge in accordance with right reason and the dictates of conscience? If a college should be more interested in the moral development of its students than it may be in imparting a few technical skills (and the two interests are not mutually exclusive), is this reprehensible? A student is, above all, a human being, with all that this implies, before he is a prospective candidate for the doctorate.

Possibly, if all our schools were more concerned with the moral development of their students, graft and corruption would be lessened. Possibly, we would not be witnessing government (or, at least, attempted government) by pressure groups, regardless of what segment of the economy these pressure groups represent. In view of the current, titanic struggle with Communist Russia, it might be well to remember the great historical lesson that nations or empires do not fall before outside pressures unless they have been first corrupted from within. Who is making the greater contribution to this struggle—those schools which emphasize moral development simultaneously with intellectual training or those schools which emphasize intellectual training only?

JOHN C. WIRTH

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BROOKLYN, NEW YORK

To the Editor:

May I offer the following comments on the paper by Ruth H. Ellis and Edward R. Linner [THIS JOURNAL, **26,** 528 (1949); see also, W. SEEGER, *ibid.*, **16,** 595 (1939)], on determining the combining weights of zinc or cadmium by dissolving them in HCl or aqua regia, and weighing their chlorides upon evaporation. (1) The metal should be weighed to the nearest centigram, not decigram, otherwise the error is too great. (2) Zinc chloride is so hygroscopic that weighings must be made rapidly. It is therefore preferable to treat a weighed quantity of zinc with HCl, measure the volume of hydrogen evolved, and calculate the weight of zinc which will displace 11,200 cc. (1.008 g.) of hydrogen at S.T.P. Or, a weighed quantity of zinc oxide may be dissolved in excess normal HCl, and the excess back-titrated with normal alkali. (3) The equivalent weights of other metals may also be determined: copper or lead, by reduction of their oxides with hydrogen; iron, aluminum, or magnesium, by reaction with HCl and measuring the volume of hydrogen as in (2); silver, by forming AgNO, then precipitating and weighing as AgCl. (4) These equivalent weights may then be used to calculate *exact* atomic weights of the metals by determination of their specific heats and conventional application of DuLong and Petit's law.

WALFRIED SEEGER

BUNDESREALSCHULE
DORBIRN, AUSTRIA

Recent Books

● SOYBEANS AND SOYBEAN PRODUCTS. VOLUME I

Edited by *Klare S. Markley.* Interscience Publishers, Inc., New York, 1950. xvi + 540 pp. 123 figs. 92 tables. 15.5 × 23.5 cm. $11.

If a person desires references regarding soybeans from 2838 B.C. to 1949 A.D., together with a short but accurate summary of each reference, this is the book to buy. The book is encyclopedic in character, each of its fourteen sections being prepared by a person thoroughly familiar with his subject. The first three chapters, while not particularly interesting from the chemical viewpoint, make excellent and instructive reading relative to the history of the production, work production, and trade and also to the structure and genetic characteristics of the soybean. These chapters are well illustrated particularly that pertaining to the agricultural processes as performed by hand labor, by animals, as well as by up-to-date machinery, the latter used in the United States. The botanical chapter carries a beautiful plate showing the color, shapes, and sizes of thirty varieties of soybean seeds.

The chapter on the chemical composition of the soybean seed is somewhat short but those pertaining to the chemical and physical characteristics of the oil and to the nitrogenous and nutritive factors occupy more than half the book. Under "influence of maturity" it is stated that "the composition of the soybean during its period of development and maturation is in a state of flux until physiological maturity is reached." Another interesting statement in the same section, from a bulletin of the agricultural experiment station of the S. Manchuria Ry. Co., is "they [Tsukunaga and Nishino] found the iodine value of the oil increased as the seed matured." It is well known that the iodine number of soybean oil is more variable than is that of most seed oils. One table, four pages in extent, giving the results of analyses of ninety-five samples of soybean oil from twelve varieties of soybeans discloses a greater variance in iodine number than is usually published elsewhere. The lowest iodine number is 99.6 and the highest 147.6. Several methods applicable to the analysis of edible oils are described. Unfortunately in the description of the determination of the thiocyanogen value the methods for the preparation of the reagents are omitted.

Under the subheading "Detection of soybean meal or flour in other materials," is given a two-page summary of twenty publications of that character. This may seem very little space, yet this reviewer, who is familiar with several but not all of the publications, can state that if work of that character is suddenly thrust upon an analyst he can ascertain by reading those two pages what methods are best suited for his problems and then can get the details from the original publications.

The last chapter relates to mechanical processing and is well illustrated with half-tone cuts of many pieces of machinery. Although this chapter is thirty-seven pages long, yet one who is interested in the industrial processing of soybeans and has had no opportunity to view various processes would welcome more detail.

There is an enormous amount of valuable information in the chapter on proteins and other nitrogenous constituents, and also in that upon nutritive factors, culled from 495 and 204 original sources respectively. When one considers the enormous amount of necessary study, reading, abstracting, and presenting the results in excellent English it is evident that the publishers, the editor, and the contributors have done well in making this valuable information available to all.

There is no index, it being reserved for inclusion in Volume II.

HERMANN C. LYTHGOE

Newtonville,
Massachusetts

● SUPERFLUIDS. VOLUME I

Fritz London, Duke University. John Wiley & Sons, Inc., New York, 1950. viii + 161 pp. 45 figs. 15.5 × 24 cm. $5.

In 1911 Kamerlingh Onnes discovered that the electrical resistance of mercury dropped to zero near 4.2°K., the boiling point of helium. Also, the viscosity of liquid helium drops to near zero below 2.19°K. In 1933 Meissner and Ochsenfeld cooled a monocrystal of tin in a magnetic field. At the superfluid transition point, the magnetic lines of force ceased going through the crystal and passed around it. The magnetic induction thus vanishes inside the superconductor along with the electrical resistance. Such behavior is not understandable in terms of classical mechanics. London deals in this book with the efforts to fit these facts into the theories of matter. He^4 apparently behaves as a Bose-Einstein gas while He^3 does not, as London anticipated. The particles of the fluid settle down with zero momentum in the superfluid temperature range. As a result, the corresponding wave lengths reach macroscopic dimensions. Such particles have zero entropy. Interpenetrating with these particles in physical space but separated from them in momentum space are random particles which carry the entropy of the system.

This book has both the fascination and limitations which go with unfinished theories. It is clearly written at the rather mathematical level required to discuss such phenomena. It should be required reading for anyone who would understand the theory of matter at the lowest temperature.

HENRY EYRING

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● CHEMICAL THERMODYNAMICS

Frederick D. Rossini, Head, Department of Chemistry, Carnegie Institute of Technology, Pittsburgh. John Wiley & Sons, Inc., New York, 1950. xix + 514 pp. 76 figs. 19 tables. 14.5 × 22 cm. $6.

This book is written as a text for a course in chemical thermodynamics for those who have studied physical chemistry and calculus. Emphasis is given to practical applications of thermodynamic principles, the material being arranged in the author's plans for instructional use and not necessarily in the order of the chronological development.

The first five chapters take up background material and introductory concepts, and the first law of thermodynamics and various energy changes are the subjects of the next five chapters. The broad topics next discussed are entropy, free energy, thermodynamic relations, energies of reaction, statistical calculations of thermodynamic functions, third law, equilibrium, solutions, equilibrium constant and free energy, electromotive force, thermodynamics of solutions of electrolytes, and applications of thermodynamic calculations. The appendix contains 13 tables of useful data, a table of symbols and their defintions, and a list of 151 references.

The author has been careful to follow a planned use of symbols which are essentially those proposed by Lewis and Randall. For discussion of solutions the symbol * is used to denote a pure component and a new superscript, $^{\circ}$, is used to denote zero concentration of solute. The superscript ° continues to be used for standard state. Further detailed symbol designations are used; for example, standard heat of formation is called $\Delta Hf°$ and standard increment in heat content for a combustion is called $\Delta He°$. Such detailed designations undoubtedly make for precise definitions but it is possible that they may add instructional problems for the teacher and the student.

Teachers will be particularly interested in Chapter 34 which contains many valuable practical calculations. High pressure and equilibrium calculations are considered; in addition information is given concerning the manufacture of isooctane, butadiene, styrene, synthetic fuels, alcohol, and of toluene from light gasoline fractions of petroleum. The sections dealing with evaluation of purity from freezing point measurements and with fractionation processes are to be commended.

A sufficient number of good problems is given at the end of each chapter and it is refreshing to find compressibility factor charts in Chapter 23 which are usable for student calculations.

In the reviewer's opinion the book is written on a level of difficulty for a graduate course rather than an undergraduate course. However, it probably could be used in a two-semester senior course if the instructor used care in selecting the material.

ARTHUR A. VERNON

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• INTRODUCTION TO AGRICULTURAL BIOCHEMISTRY

R. Adams Dutcher, **Professor of Agricultural and Biological Chemistry;** ***Clifford O. Jensen,*** **Professor of Phytochemistry;** ***Paul M. Althouse,*** **Associate Professor of Agricultural and Biological Chemistry, Pennsylvania State College. John Wiley & Sons, Inc., New York, 1951. xii + 502 pp. 23 figs. 14.5 × 22 cm. $6.**

THIS textbook was written for students who have had "... sound training in inorganic and organic chemistry." The authors express the hope that the book will also "... serve as a general reference book for students who are interested in the underlying chemical principles affecting plant and animal growth." The approach, however, is so elementary that it is doubtful if the book could be considered as a reference work since, in the main, the few references cited are to other textbooks of biochemistry. To use the book as a text would probably require a special course developed to fit the subject matter of the book.

The book is divided into three parts. Part 1, "General and Introductory," consists of eight chapters. The first is a brief history of the development of agricultural chemistry. The second deals with the elementary chemistry of living matter such as might be found in most textbooks of beginning botany or zoology. Chapter 3, the Physical State of Matter, is a review of dissociation, osmosis, surface tension, pH, etc., written at a level that would be encountered in a beginning text of plant physiology. Chapter 4, Carbohydrates, and 5, Lipids, are simple discussions of the chemical properties of these substances treated less extensively than would be found in a first course in organic chemistry. Chapter 6, Proteins, suffers greatly from brevity and omissions. Denaturation, for example, is scarcely considered. Stereoisomerism of amino acids is discussed including an illustration of a polariscope and how it is used to determine optical rotation in an early chapter, yet no specific mention is made as to whether natural amino acids are of the *d* or *l* form. Ribose is presented as a constituent of nucleoproteins, but no mention of desoxyribose appears. The classical structural formula of a tetranucleotide is presented (page 110) with a caption beneath stating, "A typical nucleic acid." Also the statement appears on the same page that, "Nucleic acid is, therefore, a tetranucleotide."

Chapter 7, Enzymes, is presented on a much higher plane than the previous chapters and is a good, though brief, survey of the subject. The next chapter, Biological Oxidations, is written from the modern point of view, but again suffers from brevity. On pages 149 and 150 a scheme for the stepwise conversion of starch to pyruvic acid is given. The phosphorylation of glucose by hexokinase is indicated but no mention is made of the necessity for a source of high-energy phosphate. The enzyme responsible for the phosphorylation of fructose-6-phosphate to fructose-1,6-diphosphate is called hexose diphosphatase. The concept of a high-energy phosphate bond is not introduced until five pages later, and then only in the sense of conserving energy derived from the oxidation of pyruvate in the Kreb's cycle. Similarly, the creation of a high-energy phosphate bond during the oxidation of 3-phosphoglyceraldehyde to 3-phosphoglyceric acid is not considered except that the Lipmann designation (~P) is used without explanation. The transfer of electrons and protons is lucidly explained and the statement, "Water is thus the graveyard of electrons from oxidized food," caught the reviewer's fancy. With a moderate amount of expansion, this chapter could be made into a good account of general respiratory processes.

Part 2, "The Plant," consists of six chapters. Seed Germination can scarcely be considered even elementary plant physiology. The Soil and Its Relation to Plant Growth is a brief reiteration of the subject matter of a beginning soils text. The mechanism of nitrogen fixation is described according to the notions of Virtanen, but no account is given of the elegant experiments of Burris and Wilson using N^{15} to describe the pathway of nitrogen fixation. The next chapter, Fertilizers, is elementary agronomy. Plant Metabolism very briefly considers photosynthesis, protein metabolism, and lipid metabolism. In view of the recent remarkable advances in photosynthesis, this subject would have profited greatly from expansion. Chapter 13, Pesticides, and 14 Farm Chemurgy, require space that could well have been used for the expansion of "... the underlying chemical principles affecting plant ... growth." It is difficult to understand how any text purporting to explain the chemical basis of plant growth could completely omit all reference to plant growth regulators, except to mention 2-4-D as a herbicide.

Part 3, "The Animal," consists of 10 chapters. While the reviewer does not feel competent to judge this section in its proper perspective, nevertheless it should be noted that Chapters 20, 21, and 22 on carbohydrate, lipid, and protein metabolism, respectively, are unsatisfactorily brief in their consideration of such important subjects. There is an appendix at the end of the book listing the nutritional requirements of farm animals.

The reviewer doubts that the subject matter of this book approaches the present level of agricultural biochemistry as it is being taught in this country. Agricultural students who can meet the severe requirements of "... sound training in inorganic and organic chemistry" are surely prepared to accept, understand, and to profit from a more thorough treatment of the biochemical mechanisms of living protoplasm.

S. G. WILDMAN

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LOS ANGELES, CALIFORNIA

• PHYSICAL METHODS IN CHEMICAL ANALYSIS. VOLUME II

Edited by *Walter G. Berl,* Applied Physics Laboratory, Johns Hopkins University. Academic Press, Inc., New York, 1951. xii + 640 pp. 16 × 23.5 cm. $13.50.

IN CONTINUING the presentation of the earlier volume of this set, this one includes "electrical, magnetic, and miscellaneous techniques." The diversity of coverage is shown by the section headings: "Metallurgical polarographic analysis and polarometric titrations," J. Heyrovsky (48 pages); "Conductometric analysis," H. T. S. Britton (53 pages); "Potentiometric analysis," H. A. Laitinen (48 pages); "Electrography and electro-spot testing," H. W. Hermance and H. V. Wadlow (77 pages); "Magnetic methods of analysis," A. R. Kaufmann (25 pages); "Determination of the area of the surfaces of solids," G. Jura (48 pages); "Surface tension measurements," M. Dole (28 pages); "Vacuum techniques and analysis," B. B. Dayton (53 pages); "Gas analysis by methods depending on thermal conductivity," E. R. Weaver (50 pages); "Measurement of radioactivity for tracer applications," A. Langer (60 pages); "Statistical analysis," J. Sherman (88 pages); and "Chromatographic analysis," W. G.

Berl (26 pages). The accompanying bibliographies range in number of entries from a minimum of 13 to a maximum of 227.

Since the reviewer is neither in a position, nor is there space, to consider each topic critically, only rather general comments seem appropriate.

In general, each subject encompasses the fundamental principles involved, the principal kinds of analytical applications (if any), and, in some cases, fairly specific details on methods. Thus, rather concise perspectives are provided for the nonanalytical major. The first three, the ninth, and the final sections especially fit this category. Others, such as electrography and radioactivity, are definitely something more. The analytical aspects of electrography and radioactivity are so new that most analysts will welcome these summaries.

One's reaction to a work of this kind is conditioned by his concept of the place and the work of analysts and of the subject matter properly belonging to chemical analysis. Probably no two individuals could agree on the answer to the question of what should be treated where. For example, should the theory and method of use of the equal-arm balance be presented in the mechanics section of a treatise on experimental physics, in a monograph on physico-chemical measurements, or in a textbook on gravimetric methods of chemical analysis? Perhaps the answer is, in all of them.

In stating the following questions, then, the reviewer is really only expressing personal uncertainties. Do surface area or surface tension measurements as described here furnish information on what constituent is present or how much there is? That is, do these topics belong in chemical analysis? The analyst, of course, might want to check such a property as a specification; but this is equally true for many other physical properties not included. Where does statistical analysis belong? Certainly all serious students, dealing with measuring numbers in many fields, must deal with it. Usually students in chemistry encounter measurement first in elementary physics or in quantitative chemical analysis by titrimetric or gravimetric methods. Since chromatographic analysis, as presented here, is a separative operation, is it sufficiently unique among methods of separation to warrant isolation from the others?

The reviewer would have suggested certain additions, such as the following applications: new polarographic techniques and polarography for organic systems; magnetic methods for certain separations; and control charts in statistical evaluations.

These summaries will be adequate for many people. Those not satisfied will find in the bibliographies citations to more comprehensive treatments.

M. G. MELLON

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● TOXICOLOGY OF URANIUM

Edited by *Albert Tannenbaum,* Director, Department of Cancer Research, Medical Research Institute, Michael Reese Hospital, Chicago. McGraw-Hill Book Co., Inc., New York, 1951. xxvi + 333 pp. 68 figs. 138 tables. 16 × 24 cm. $3.

THE concentrated research under the direction of the Manhattan Project on the toxicology and pharmacology of uranium that was performed by a group of scientists at the Metallurgical Laboratory of the University of Chicago and the Medical Research Institute of Michael Reese Hospital, Chicago, is reported in this volume of the N. N. E. S. The 14 original papers and two literature reviews are preceded by a clear and concise survey of the significant findings. The subjects covered include the nature of uranium poisoning, the distribution and excretion of the metal, and the gross and microscopic pathology that follow exposure to it. Some biochemical studies are also presented and discussed.

Although most of the work was done with uranium 238, uranium 233 was used for some tracer studies. The relative toxicities of various uranium compounds and various routes of administration were investigated, and several species of animals were studied. The major portion of the work involved uranyl nitrate injected subcutaneously or fed to mice. The subcutaneous route of administration complicated unnecessarily the retention, excretion, and distribution studies because of residual material at the injection site. This difficulty could have been removed simply by injecting the material intravenously.

The editor points out that this is not a textbook of the toxicology and pharmacology of uranium and that it is not a compilation of all the Manhattan Project studies on uranium. However, it is a valuable contribution to our knowledge of the biological effects of uranium 238. The research was initiated because of the need to protect the health of those workers in the Project who were actively engaged in uranium operations. Since the information was required at once, no excuse need be made for the small numbers of animals employed and the lack of completeness of some of the work. Sufficient data were rapidly accumulated to indicate that uranium 238 is less of a hazard to personnel exposed to it than mercury or lead.

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● PROGRESS IN BIOPHYSICS AND BIOPHYSICAL CHEMISTRY. VOLUME I

Edited by *J. T. Randall* and *J. A. V. Butler.* Academic Press, Inc., New York, 1950. viii + 279 pp. 119 figs. 17 tables. 16 × 25.5 cm. $6.80.

THIS volume is a welcome addition to the list of biological review journals which have developed in such large numbers in recent years. It must not be considered just another review journal, however, for in certain respects it is quite unusual. To the present reviewer, who has found certain of these journals to be quite useless except possibly for their bibliographic compilation, the present volume is refreshingly different. Not only is the quantitative point of view a dominant feature of this volume, but each article is written by a specialist who appears to have thoroughly digested and organized the material before writing it in its finished form. As a result the reader obtains a full view of each subject rather than a mass of unrelated, useless tidbits of information. The book is not easy reading, on the whole, but for advanced students who wish a comprehensive review of certain phases of biophysics, biophysical chemistry, physiology, and the theoretical basis of specialized techniques this volume is highly recommended. The following is an attempt to indicate the scope of the subject matter.

The first chapter entitled "Properties of solutions of large molecules" is written by H. Gutfreund and is concerned mainly with some of the methods used to determine certain physical constants and the results of measurements of these constants in protein solutions. Included in this chapter is an interesting thermodynamic derivation of the Van't Hoff osmotic pressure equation for dilute solutions. Some discussion is also devoted to the Donnan equilibrium and to the problem of the criteria of homogeneity in protein solutions. A brief enumeration is included of certain physical constants for six important biological macromolecules, *i. e.*, hemoglobin, myoglobin, ovalbumin, serum albumin, insulin, and beta-lactoglobulin.

The second chapter is by K. M. Rudall on the subject of "Fundamental structures in biological systems." This is a well-written review of recent studies on the molecular structure of polypeptides, proteins, polysaccharides, and polynucleotides. A considerable portion of the chapter is devoted to a consideration of the beta-type (extended) polypeptide structure and the types of bonds which exist in such a structure as well as to the alpha-chain. Some discussion is devoted to the alpha → beta transformation as well as to the interesting phenomenon of supercontraction.

Chapter three is a short but important treatment by G. Oster of the subject "Scattering of visible light and X-rays by solutions of proteins." In this discussion the author develops the theo-

retical basis for the analysis of size, shape, and relative positions of protein molecules by the technique of scattering of visible light and X-rays. Four cases are considered. The first is that of small independent particles, *i. e.*, particles in a thermodynamically ideal solution, and whose largest linear dimension is about one-tenth the wave length of the radiation. For a monodispersed system of such colorless particles the Rayleigh inverse fourth power of the wave length law holds within the wave length limits where there is no absorption. From such a Rayleigh plot the molecular weight may be determined. The author points out that values of molecular weights determined by the light scattering method agree reasonably well with the results of other methods. The second case which is discussed is that of small nonindependent particles. The equation for these particles is developed on the assumption that light scattering follows the Smoluchowski-Einstein equation. From the application of this equation the molecular weight may be determined as well as a function B whose value is determined by both the shape and interactions of the particles. The third case, that of large independent particles, *i. e.*, particles with a linear dimension comparable to, or greater than, the wave length of the incident radiation is treated on the basis that the theoretical angular distribution of the scattered light is given by the solution of the electromagnetic problem of a plane wave falling on a particle whose index of refraction is close to that of the medium in which it is immersed. For particles of low relative refractive index, particle size may be determined from the dissymmetry of scattering. For this all that is needed are two measurements of intensity of scattering at two equal angles on either side of 90°. The author shows how size, shape, and molecular weight may be studied by such dissymmetry measurements and it is pointed out that the dissymmetry method may be useful in a number of biologically important systems where change in shape of protein molecules is believed to occur. The fourth case, that of nonindependent large particles, is treated as a case of X-ray scattering by nonideal gases and liquids.

Chapter four by E. E. Crane summarizes a great deal of useful information on bioelectric potentials. A brief historical review is first given followed by a tabulation of some of the best known plant and animal sources (tissues and organs) of biopotentials. A discussion, along classical lines, of the physicochemical causes of these potentials is presented, following which, the author undertakes the difficult job of attempting to relate these potentials to physiological events. Some of this discussion involves ovulation and ovulation potentials, wounds and the potentials which arise in association with such injuries, the electric organs of fish and the potentials which these organs produce, and the important problem of the biopotentials arising from secretory structures. This chapter is concerned exclusively with the so-called steady potentials, and the action potentials as well as other transients are entirely omitted. A worker in this field cannot be critical of this omission because the action potentials, especially in connection with the nervous system, have been reviewed almost to satiety.

Chapter five is a brief summary by A. F. W. Hughes of "Phase-contrast microscopy in biological research." This chapter gives a bit of the history of the phase-contrast microscope, indicates its advantages and limitations in biological research, and itemizes some of the most recent publications in this field. A technical discussion of the theory and construction of the phase-contrast microscope is omitted but references to this are cited.

Chapter six, entitled "Local refractometry: the observation of transparent inhomogenous matter" is written by J. St. L. Philpot and is concerned with the theories involved in the observation by optical methods of biological materials as in microscopy, ultracentrifugation, electrophoretic migration, etc. The chapter, which contains a valuable summary of certain phases of mathematical optics, discusses afocal methods, focal methods, amplifocal methods, and aperfocal methods. This chapter will be of great value to specialists who wish to have a more thorough understanding of the methods employed in the laboratory.

A. Engström is the author of the seventh chapter which is entitled "Use of soft X-rays in the assay of biological material." This is an interesting account of the use to which soft X-rays have been put in the histological and cytological examination of biological material. The author first shows that with X-rays in the region of 2–50 Å. it is theoretically possible to make absorption measurements in a sytem composed of a layer of single cells. Some of the history and methods of microradiography are discussed including the technique of true X-ray image production by the use of monochromatic radiation and a crystal grating. In addition, there is a discussion of the theory and technique of the method for determining the mass of cell structures. The author describes his own work in which the transmission to polychromatic soft X-rays by a biological specimen is compared with the transmission in a reference system consisting of a step wedge of thin collodion foils. The transmitted rays are allowed to strike the emulsion of a Lippman film and the microradiogram thus obtained is enlarged by photomicrography. The density of various cell structures is compared with the density of the wedge and the relative mass in units of the wedge for various cytological structures is determined. A number of applications of this technique and photographs of selected cells and tissues are given. Single nerve fibers with nodes of Ranvier are shown as well as striated muscle fibers with well-developed cross striations. Some rather striking photographs showing marked differences between nucleus and nuclear structures and the cytoplasm were especially interesting to this reviewer. Most striking was the high density of the chromosomes in *Chironomus* larva salivary glands and the mass differences of the chromosome bands in the Chironomus preparation.

The author also indicates that the presence of absorption edges at particular wave lengths makes possible the use of X-rays for the quantitative determination of different elements. Using the K-absorption edges it is concluded that the major elements of biological interest may be theoretically determined by X-rays with the method outlined above. Curves are shown of the concentration of calcium and phosphorus in a tooth as a function of distance from the apex of the tooth as well as a graph of the concentration of sulfur in the *stratum corneum* of the skin.

Chapter eight is a timely account by J. F. Loutit of man's tolerance for radioactive isotopes. The author emphasizes the possible future danger in the contamination of air and water supplies with long-life radioactive fission products and reminds us that information about the maximum tolerable contaminating dose is badly needed, but that due to ignorance of the biological variables the present information is not entirely dependable. The author then considers the meager and uncertain information of the metabolism of radium based on some clinical observations and the few existing experiments in which volunteers were employed. Radium is eliminated by way of the feces, urine, and expired air (radon). Though figures for elimination vary, there is general agreement that a large proportion of the ingested radium is eliminated. About 1 per cent is retained in the bones, and this is rather firmly bound although some shift can occur. Toxic effects of radium include bone necrosis, anaemia, and osteosarcoma. Mesothorium also appears to have some of these effects. The author also speculates on a comparison of the effects of radium with certain of the fission products. He considers that Sr^{89}, Sr^{90}, and Ba^{140} should be expected to be deposited diffusely in bone, like radium and calcium, whereas certain other elements (yttrium and cerium) concentrate at the periosteal and endosteal surfaces, thus creating certain special problems. Products which do not concentrate in bones (Xe^{133}, Cs^{137}, Ru^{103}, Ru^{106}) must of course be treated differently from radium in calculations of maximal permissible dose. This entire chapter is an implicit announcement of the need for precise, controlled, and responsible experiments of the effects of radioisotopes on the human organism.

The last chapter by M. G. M. Pryor on "Mechanical properties of fibres and muscles" is a difficult but a most stimulating section of this volume. The author first considers the thermodynamic behavior of certain elastic substances when under strain. Rubber is given considerable attention especially with regard to some of the ideas which have been proposed for the behavior of the rubber molecule chains. Some discussion is also given to imperfect rubbers and the elastic aftereffects which these materials

give. The load-length curve of polyvinyl chloride shows such plastic behavior, and human hair responds to load as does polyvinyl chloride. Two theoretically possible elastic power cycles are next discussed. These are the potential energy cycle and the entropy (kinetic) cycle. Several conceptions of potential energy cycles are given and the difficulties which arise in applying these to muscle contraction are stated. The entropy cycles are given as (1) a heat engine analogous to a Carnot cycle and (2) a chemical engine in which the attractive forces between molecules are controlled chemically.

To obtain information on the nature of the power cycle in biological systems the dynamic modulus is considered by the author to be of value. This modulus is obtained by subjecting the system under study to a rhythmically varying load. The dynamic modulus varies with the frequency of load variation and this response to frequency yields valuable information about the properties of the test system. The author first pictures and describes his own apparatus for the measurement of the dynamic modulus and then gives some of his own results on a model system consisting of pheasant leg tendons contracting when treated with a solution of potassium mercuri-iodide.

The last section of this chapter deals with muscle. The author reviews previous work and the results of his own experiments as to the effects of stimulation on viscosity and the variations of the dynamic modulus with frequency. The conclusion is reached that the kinetic theory offers a more reasonable concept of the behavior of muscle unless one wishes to add additional complications to the potential energy hypothesis. Muscle contraction is then visualized as a change of the muscle proteins from the resting state, when they are in a semicrystalline condition or when intermolecular forces are high, to the active state when there is a decrease in the forces binding protein chains and a reduction of the orientation. The immediate stimulus for this change is assumed to be the addition of a plasticizer—perhaps ATP—which reduces the intermolecular forces. Recovery of the orientated state is assumed to follow upon the enzymatic destruction of the ATP.

FREDERICK CRESCITELLI

UNIVERSITY OF CALIFORNIA
LOS ANGELES, CALIFORNIA

● WATER TREATMENT

Eskel Nordell, **Administrator, Analytical Laboratories, Research and Pilot Plant Divisions, The Permutit Company. Reinhold Publishing Corp., New York, 1951. vii + 562 pp. 126 figs. 162 tables. 16 × 23.5 cm. $10.**

THOSE who are interested in the industrial treatment of water will find this book to be of great practical value. Every phase of industrial treatment is touched upon. The principles involved in the various processes are clearly explained and the standard industrial practices are so completely covered as to leave little more to be desired. There is a well-selected bibliography at the end of each chapter. Many definitions, equivalents, conversion factors, and tables are arranged in 28 pages of appendix.

There are 18 chapters which cover source and character of supply; the nature and significance of impurities present, whether dissolved minerals, gases, turbidity, or microorganisms; water requirements and type of treatment required for various industries; boiler feedwater practices; chemical feeder characteristics; removal of suspended matter, turbidity, and color; coagulation and filtration; methods of iron, manganese, and silica removal; softening and demineralizing methods.

Many water analyses are tabulated to illustrate the wide variations in quality of sources of supply. These analyses have been recalculated so that all constituents, even to nitrate and bromide, are expressed as calcium carbonate. The tables of conversion factors in the appendix will be welcome to many who will wish to think of nitrate or bromide as such rather than their equivalents of calcium carbonate. One wishes that space had been devoted to methods of analysis for constituents other than dissolved gases. The titration method for determining free carbon dioxide is given in detail. In view of the importance of pH in relation with water treatment problems some discussion of this would have been desirable.

The chapter on water requirements and necessary treatment for various industries is very complete. The classified listing of water-treating equipment and types of equipment used in various industries will be valuable not only to students and consultants but also to engineers of city water departments. Chemical feeders are classified and each type of machine is described along with its advantages and limitations for the job to be performed. The basic principles of coagulation are discussed as well as the properties of those chemicals used as coagulants. The zeolite process of softening is quite complete. This is followed by an excellent discussion on hydrogen-cation exchange and demineralizing processes including mixed bed demineralization. Both hot and cold lime-soda softening processes are described, from early conventional methods to the newer catalyst methods. The final chapter on silica removal will bring the reader up to date in important methods of treating waters for high-pressure boilers.

HENRY C. MYERS

CALIFORNIA WATER & TELEPHONE COMPANY
NATIONAL CITY, CALIFORNIA

● ANALYTICAL CHEMISTRY OF THE MANHATTAN PROJECT

Editor-in-chief: *Clement J. Rodden,* New Brunswick Laboratory, U. S. Atomic Energy Commission. McGraw-Hill Book Co., Inc., New York, 1950. xx + 748 pp. 151 figs. 68 tables. 16 × 23.5 cm. $6.75.

THE wartime Project made unusual demands upon its analytical chemists. Not only were many of the rarer elements studied with a new intensity and in novel combinations, but trace concentrations of all sorts acquired a new importance because of the high neutron absorption cross section of many otherwise harmless contaminants. The whole analytical literature of such elements as thorium and uranium was most thoroughly sifted and in this book has been largely rewritten as a result of Project studies. In the first part of the book about 200 pages are devoted to uranium and thorium and 300 more to the rest of the individual elements. The remaining 250 pages discuss special analytical laboratory equipment and techniques. This section is illustrated with diagrams and photographs of special Project apparatus. The book as a whole serves as a most useful supplement to such works as Hillebrand and Lundell's "Applied Inorganic Analysis."

NORRIS F. HALL

UNIVERSITY OF WISCONSIN
MADISON, WISCONSIN

● FLOW MEASUREMENT WITH ORIFICE METERS

Reid F. Stearns, Robert M. Jackson, Russell R. Johnson, **and *Charles A. Larson,* Standard Oil Development Co. D. Van Nostrand Co., Inc., New York, 1951. xviii + 350 pp. 160 figs. 26 tables. 18.5 × 26.5 cm. $7.50.**

THIS book is one of "The Esso Series" and is primarily directed to engineering, technical service, and instrument groups concerned with process control, test work, and plant start-ups in the petrolum industry. It does a good job of collecting in one book all of the information necessary for the practical application of orifice meters, although the physical data presented are for the most part limited to fluids found in petroleum refining. A number of example calculations worked out in detail may be of interest to students.

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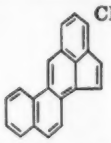

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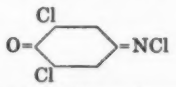

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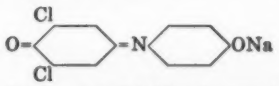

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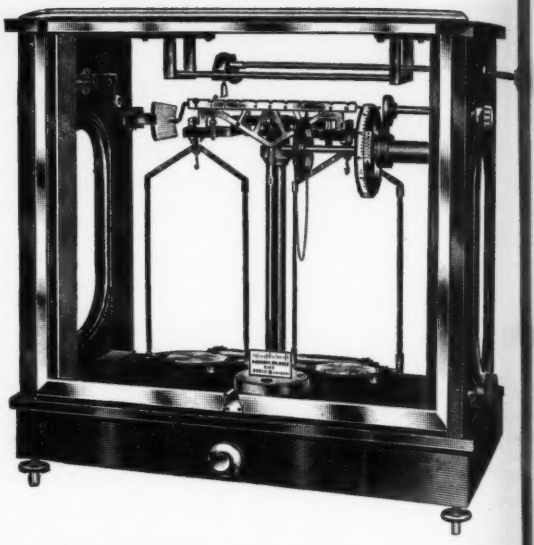

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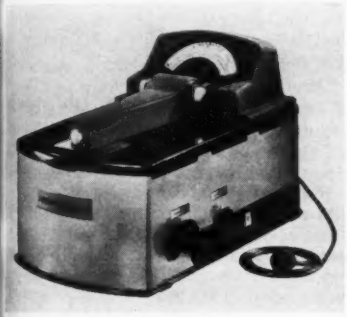
Out of the Editor's Basket

Photometer

The Macbeth Corporation, Newburgh, New York, has announced the Macbeth-Ansco Color Densitometer, a sensitive precision photometer permitting measurement of color densities in narrow spectral ranges, as well as visual densities over an unusually wide range. With accessory equipment reflection densities of opaque samples and transmission densities of liquids can also be measured. The instrument is described in Bulletin No. 144.



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A highly efficient detergent, compounded especially for cleaning glass, porcelain, and metal laboratory ware, has been announced by the Arthur H. Thomas Co., West Washington Square, Philadelphia 5, Pennsylvania.

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Millivoltmeter

An indicating millivoltmeter that contains a galvanometer unit, providing greater versatility and accuracy, has been introduced by Minneapolis-Honeywell Regulator Co.

The unit is comparatively free from the effects of vibration. It can be actuated by thermocouples and Radiamatic pyrometers, tachometers, resistance thermometers, or any source of millivoltage.

Remote Pipet Control

The production of a remote pipet control has been announced by Nuclear Research and Development, Inc., 1094 Sutter Ave., St. Louis 5, Missouri. This instrument, designed for use with radioactive liquids, performs all the necessary pipet operations without the necessity of handling the pipet at any stage.

New Gas Data Book

The Matheson Co., Inc., of East Rutherford, New Jersey, has just published the second edition of their gas data book covering 61 different gases. It describes the properties, toxicity, safety devices, precaution in handling, and recommended controls for each gas. Several new features have been added including a cylinder valve outlet chart and temperature pressure charts for 29 different gases. Price of the book is $2.00 per copy.

Spectrochemistry

"Spectrochemistry—a long title for a short story" is a brief, simple description of this method of analyzing with light. It was produced to familiarize people quickly with the principles of spectrochemistry. The diagrams, in full color, were designed primarily for educational rather than sales purposes. This folder will be of value to teachers, chemists, technologists, and students interested in either Clinical or Industrial spectrochemistry and colorimetry.

Copies of this bulletin, No. 118-139, are available upon request from Coleman Instrument Inc., Maywood, Illinois.

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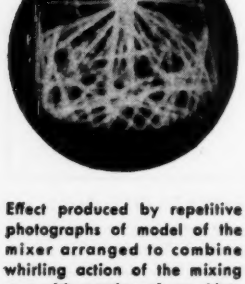

Effect produced by repetitive photographs of model of the mixer arranged to combine whirling action of the mixing arm with rotation of can. Note how thoroughly the entire space occupied by the batch is covered by the agitator.

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Interlingua

Dr. Austin M. Patterson has called our attention to the activities of the International Auxiliary Language Association (IALA), 420 Lexington Ave., New York 17, New York which is advocating a new auxiliary language, Interlingua. Dr. Patterson, who has followed closely the efforts to establish an international language, feels that "Interlingua" differs from other artificial languages devised by individuals in that it is the result of a scientific search for a usable common vocabulary in our natural languages. He says: "For many years IALA has conducted an analytical study of some of the Western languages most important for science, with a staff of specialists and with the aid and advice of prominent linguists in this country and abroad, in order to isolate the common element."

IALA has just published an "Interlingua-English Dictionary" soon to be followed by an English-Interlingua part.

Thinking that our readers may be interested in a sample of the language, we are reproducing the Interlingua version of the "History of UNESCO," translated from the "Dictionary of International Scientific Organizations." See how easily you can understand it!

In novembre 1942 le ministros de education del governamentos alliate conveniva in London sub le presidentia del ministro de education de Grande Britannia. Iste convention deveniva permanente, e de 1942 a 1945 le conferential del ministros alliate de education studeva un programma de rehabilitation educational e cultural in le paises occupate. Le conferentia concludeva que in illo esseva le embryo del futur organisation international de education, e que un de su deberes esserea le examination del possibilitate de facer un practic de un tal organisation post le guerra. Inter le duo guerras un simile organisation habeva existite, a saper, le Instituto International de Cooperation Intellectual, le qual dependeva del Societate del Nationes e persequeva le meme fines. In le anno 1944 le governamento del Statos Unite decideva se etiam de participar post le guerra in le reconstruction educational del paises devastate. A fin de render clar su intention, illo decideva se de collaborar sin retardo in le labor del conferentia del ministros alliate de education. In april 1944 le conferentia declarava que immediatemente post le stabilimento del pace le Nationes Unite deberea instituer un organisation per restaurar le medios de education e le hereditage cultural in le paises devastate. *Le Carta del Nationes Unite.*— Alicum menses ante le conferentia de San Francisco le representantes de vinti republicas american que habeva convenite in Chapultepec (Mexico) in februario e martio 1945, habeva adoptate un resolution concernente le utilitate del creation de un institution international specialmente responsabile pro incoragiar le cooperation intellectual e moral inter le nationes. Nimerose delegationes supportava simile propositiones in le assemblea general de Nationes Unite que conveniva le prime vice in San Francisco. Finalmente le assemblea approbava unanimemente un declaration francese con le senso sequente:

I. Le pace mundial debe esser basate super comprehension e accordo mutual; II. Le Nationes Unite debe assecurar que le cultura essera accessibile a omne homines; III. Il es le deber del Nationes Unite de facilitar le excambio e le dissemination de information concernente le varie aspectos de lor vita national.—Le declaration francese proponeva etiam que le Nationes Unite debeva convocar promptemente un conferentia general a fin de minutar le statutos de un organisation international de cooperation intellectual. Supportate tanto per organisationes private tal que le consilio american de education como per le varie organos del Nationes Unite iste projectos resultava finalmente in un initiativa conjuncte del governmentos francese e britannic. Le duo governamentos invitava omne statos que esseva membros del Nationes Unite, a inviar representantes a un conferentia convocate a fin de crear iste organisation de cooperation intellectual. Le conferentia habeva loco in London del prime al dece-sexte de novembre 1945; a illo assisteva le representantes de quaranta-quatro governamentos e observatores delegate per le plus importante organisationes intergovernamental. In duo septimanas le conferentia de London poneva se de accordo concernente le texto que deveniva le constitution de UNESCO. Ante le clausura del conferentia de London il esseva decidite de convocar in Paris le proxime anno le prime session del conferentia general que debeva instituer le organisation officialmente. In novembre 1946 delegatos e observatores de quaranta-sepete nationes conveniva in Paris que habeva essite selegite como le permanente quartiero general del organisation. Trenta-sepete nationes ratificava su constitution immediatemente. UNESCO habeva definitivemente venite al mundo. Ab iste tempore le numero del statos membros habe crescite a cinquanta-nove. Le conferentia general de UNESCO ha jam convenite cinque vices. Le prime session in Paris in novembre 1946 minutava un programma initial del labor e appunctava Dr. Julian Huxley como director general de UNESCO pro un periodo de duo annos. Le secunde session habeva loco in Mexico City in novembre e decembre 1947. Le director general presentava un reporto super le labor initial de UNESCO. In su tertie session in Beirut in decembre 1948, proque le officio de Dr. Julian Huxley habeva arrivate a su fin, senior Jaime Torres Bodet, le ministro del extero de Mexico, esseva eligite como director general pro sex annos. Le quarte session habeva loco in le domo de UNESCO in Paris in septembre 1949. Le quinte session habeva loco in Florentia in le anno 1950.

"Counters"

A four-page folder entitled "Counters" is available from the New York University College of Engineering, Bureau of Public Information, New York 53, New York. This illustrated folder explains the behavior of electrons, positive ions, ion clouds, impulses, and the elements of the Geiger counter. Another section deals with penetration and decaying cosmic ray particles. Data are also given on special counting circuit arrangements.

Determination of Carbon

The Burrell Combustron, an electronic instrument for the rapid and accurate determination of carbon by combustion, has been announced by Burrell Corporation, 1942 Fifth Ave., Pittsburgh, Pennsylvania, and is described in its Bulletin No. 319. Some of the features included are instant heating, rapid analysis, visible combustion, a Vycor reaction tube, and availability in one or two tube models.

The Care and Handling of Glass Volumetric Apparatus

A new booklet discussing the proper handling, care, and calibration of volumetric glassware has just been released by Kimble Glass, Division of Owens-Illinois Glass Company.

Titled "The Care and Handling of Glass Volumetric Apparatus," this publication was months in preparation and contains accurate basic information for scientific and clinical laboratories and for advanced students in chemistry.

A total of 16 colored figures and 6 tables describe such things as: systems of weights and measure, cleaning apparatus, reading the meniscus, gravimetric and volumetric calibration, and the drainage time of burettes and pipettes. The booklet is divided into four chapters.

Copies of this publication may be had without cost or obligation by writing Kimble Glass, Box 1035, Toledo 1, Ohio.

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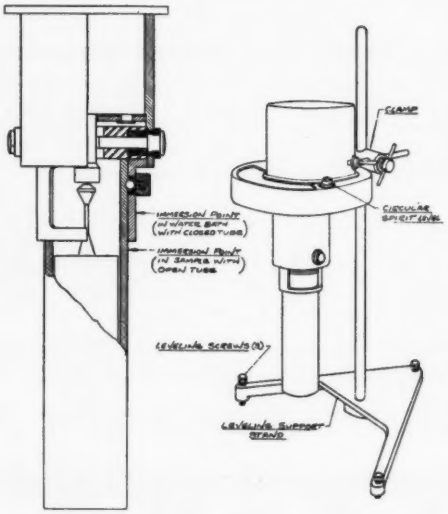
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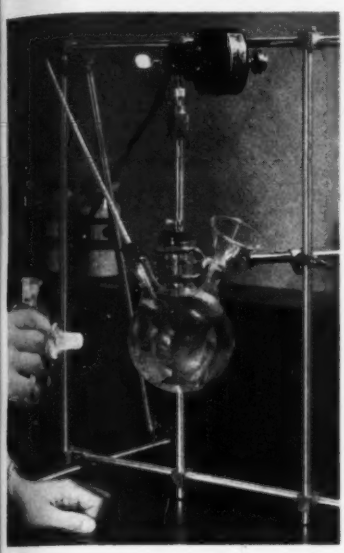

a new Umbrella Stirrer which has four stainless steel blades that can be closed to pass through the neck of a flask, then opened for maximum stirring effectiveness. They can be twisted while within the flask, producing a wide variety of shearing actions. The stirrer is manufactured by Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pennsylvania.

Electronic Thermometer

A new electronic resistance thermometer less expensive than nonelectronic complete resistance thermometer equipment, has been introduced by the Emil Greiner Co., 20–26 North Moore St., New York 13, New York.

Employing a new resistance bulb in which a tungsten coil is sealed in solid pyrex glass or molybdenum in solid quartz, the thermometer provides rapid response. A new principle in the balancing bridge simplifies calibration so that the instrument is practically direct reading. It measures temperatures to 1000°C. with an accuracy of 0.1° and a sensitivity of 0.01°.

Demineralizer

The Bantam Demineralizer, produced by Barnstead Still & Sterilizer Co., 2 Lanesville Terrace, Boston 31, Massachusetts, is equipped with a direct reading meter which indicates water purity. The instrument is calibrated in parts per million and also in ohms.

Hand Spectroscope

Laboratory Equipment Co., 526 Folsom St., San Francisco, California, has announced a hand spectroscope with a comparison prism, enabling spectra to be examined from two sources simultaneously. The instrument has a high-quality slit and adjustment, with a 10° dispersion prism arrangement.

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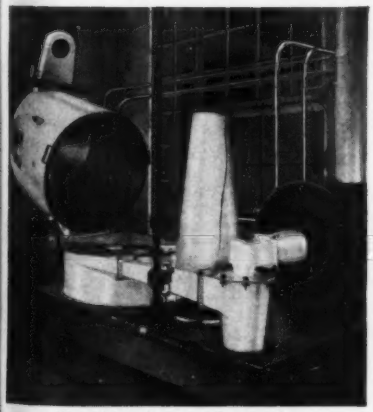

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*Ref. — L. G. Longsworth, Anal. Chem., p. 346, Feb. 1951.

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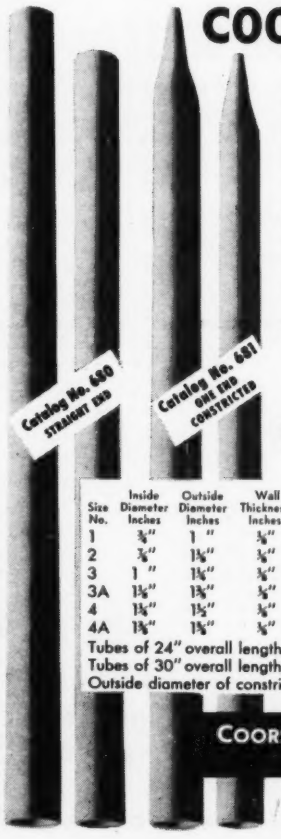

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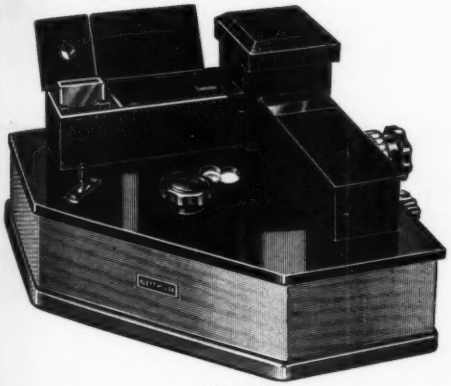

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In revising "Polarographic Method of Analysis," the author added much new material making the second edition virtually a new book. It has been completely reset, revised and enlarged to 209 pages. Following is a list of some of the new material added to this edition:

CHAPTER I Discussion of polarization, depolarizers, and sign of electrode potentials.

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CHAPTER IV Electrode deposition of metals from complex metal ions. Reaction of organic compounds in unbuffered solutions and demonstration of buffer action. In this a suggestion is made about using the method of buffer action as a method of the quantitative analysis of non-electroactive substance. Influence of temperature and solvent on the half wave potential. Reduction of hydrogen ions at the dropping mercury electrode.

CHAPTER V Polarometry is now treated as a separate chapter and has been extended.

CHAPTER VI is completely new. It treats such recent developments as differential polarography, derivative polarography and oscillographic polarography. Also in this chapter are discussed newer developments in electrodes which are used for polarographic analysis, such as the multiple dropping mercury electrode, the knock-off electrode, and the streaming mercury electrode and various forms of platinum electrodes, such as the stationary and rotating platinum electrodes, and the by-pass electrode.

CHAPTER VII is the old chapter 5, to which have been added method of standard addition, method of step quotients, pilot ions, and their use, the electrolysis prior to polarographic analysis, the anomolous wave and the protein index.

CHAPTER VIII In this chapter are discussed the various factors which may cause irregularities in polarographic curves. Also given is the information which makes it possible to characterize any given electrode and to select a capillary for a dropping mercury electrode with a desirable drop time and drop weight.

An *appendix* has been added in which are given the potentials of reference electrodes as well as a list of useful buffers for polarographic analysis. Finally, an *index* has been added which should make the book much more valuable than its predecessor.

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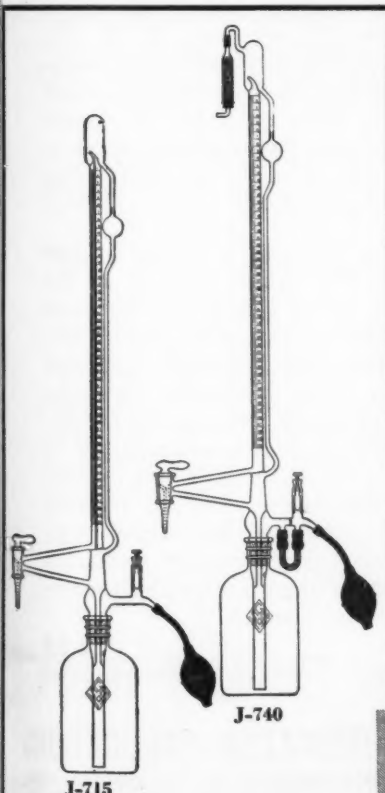

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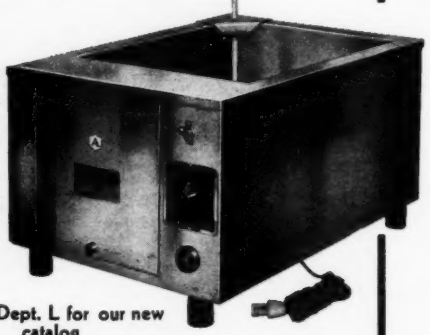

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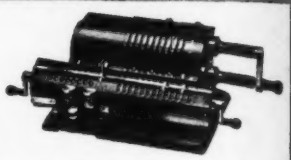

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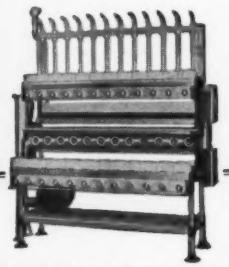

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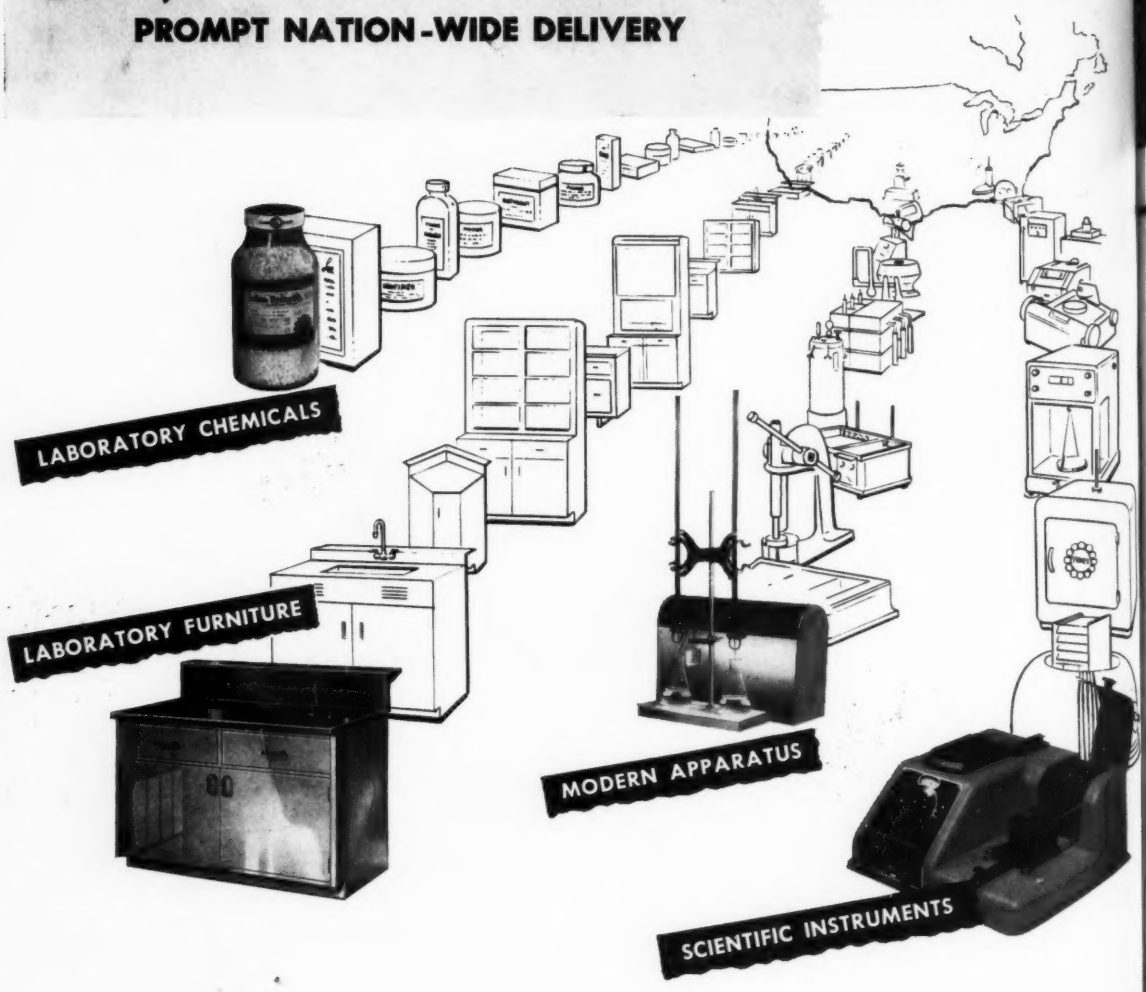

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